LOGGING INDUSTRY RESEARCH ASSOCIATION

NEW ZEALAND

PROJECT REPORT

LOTUS SERIES II HAULER TRIAL REPORT

P. R. 20 1982

N.Z. LOGGING INDUSTRY RESEARCH ASSOCIATION (INC.)

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N.Z. Logging Industry Research Assoc. Inc.

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LOTUS SERIES II HAULER
TRIAL REPORT

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SECTION 1

ACKNOWLEDGEMENTS

The report on the Lotus Series II hauler would not have been possible without the assistance and co-operation of a number of companies; and this is acknowledged by LIRA. Companies involved in the trials were :

FOREST INDUSTRIES DEVELOPMENT COMPANY, JAMAICA

LOTUS ENTERPRISES LIMITED

R.C. MacDONALD LIMITED

TASMAN FORESTRY CENTRAL DIVISION

NEW ZEALAND FOREST PRODUCTS

LUCAS INDUSTRIES (N.Z.) LTD

LOGGING INDUSTRY RESEARCH ASSN.

LOGGING CONTRACTOR, KEITH TRAVERS AND CREW

This report has been compiled from a series of studies and tests carried out on the Lotus Series II hauler while it was in a productive situation.

INTRODUCTION

The Lotus Series II is a mobile truck mounted four drum skyline hauler, designed to handle both thinnings, and the smaller piece size expected from clear felling minor species.

This report describes a series of trials carried out with the Lotus Series II hauler to determine the specifications and performance capabilities of the unit for the owners; Forest Industries Development Company of Jamaica.

BACKGROUND

The Forest Industries Development Company of Jamaica (FIDCO), through the World Bank, called for tenders for the supply of two mobile haulers.

The successful tenderer was Lotus Enterprises Ltd, who have designed and built two machines to comply with the design and performance schedule approved by FIDCO.

As this Series II hauler has been designed and built specifically to suit the Jamaican operation, Lotus Enterprises Ltd, on behalf of FIDCO, requested that the Logging Industry Research Association (LIRA), as an impartial research group representing the logging industry, test the Lotus Series II hauler, and certify that the hauler's design and performance capability met the agreed specifications.

SUMMARY

The Lotus Series II is a truck mounted four drum skyline hauler that has been designed to handle thinnings, and the smaller piece size expected from clearfelling minor species. The machine has been on trial in Tasman Forestry's Tauhara Forest, and is owned by the Jamaican company, Forest Industries Development Company.

The objectives of the Lotus Series II trials were to firstly satisfy the Jamaican company, FIDCO, that the hauler met the agreed specifications, and secondly, to evaluate the machine in a production situation.

LIRA's involvement was to act as an impartial body to test and certify the machine according to specification, and to investigate and report on the potential productivity of the Series II.

LIRA can confidently report that the Lotus Series II under trial, not only met, but in some cases exceeded, the performance requirements of the specification, which were :

	Line Speed (FT/Min)	
	Specification	Performance
Mainrope mid-drum, 80 hp (2000 R.P.M.)	323	400
Mainrope mid-drum, 100 hp (2500 R.P.M.)	423	524
Tailrope mid-drum, 80 hp (2000 R.P.M.)	391	497
Tailrope mid-drum, 100 hp (2500 R.P.M.)	512	651

	Line Pull (tonnes)	
	Specification	Performance
Mainrope mid-drum, 80 hp (2000 R.P.M.) Relief valve setting 2550 P.S.I.	3.38	3.405
Tailrope mid-drum, 80 hp (2000 R.P.M.) Relief valve setting 2800 P.S.I.	2.79	2.806

The production trial site, although not ideal, provided a more than adequate testing ground for the hauler. Piece size recorded at .84 m^3 average, fluctuated between short broken tops to full tree lengths over 1.8 m^3 in volume. The average number of pieces and volume per turn during the trial was 1.68 and 1.4 m^3 respectively.

The performance of the Series II during the production trial was impressive.

In conclusion, these trials were not only testing the specification against performance of the Series II Lotus, they were also proving that hydraulic drive's in haulers are both viable and competitive with existing, conventional mechanical drives. The principles of using hydraulic's open up a new concept of power and speed combinations which are likely to be manifested in future machines. The potential to increase power and speed make the Series II a highly versatile machine that could be used in thinning or clearfelling, providing rope sizes are matched to the volume of timber per turn, being yarded.

The New Zealand company of Lotus Enterprises Ltd must be commended for its perseverence in developing this concept to a production stage.

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MACHINE DESCRIPTION

2.1 General

The Lotus Series II is a truck mounted three-drum hauler with an additional fourth drum for the strawline. It has an integral tapered box steel tower that can be hydraulically raised and lowered. Oil pressure generated by a hydraulic pump is used to drive the drum motors as selected. The oil pump is powered by a separate aircooled diesel engine, mounted at the front of the machine. This engine also drives a smaller hydraulic pump to operate the strawline drum motor, hydraulic ram for raising the tower, and the lateral stabiliser legs, which are all on a separate hydraulic circuit. The hauler is guyed to the rear with three hand-wound guy ropes, and to the front by two manually set check guys. Four reinforced screens protect the engine and hydraulic components from damage, and these can pivot down to allow servicing access. The operator and controls are well protected by a robust box section steel cab mounted at the rear.

The machine layout was considered simple and orderly, with all major components well placed for servicing access. The hydraulic oil tank was well positioned for oil site gauge level checking, and re-filling, and access to check fuel and oil levels on the engine was also good.

Component replacement would be relatively easy. The engine unit is fitted to a separate bed frame and could be easily removed, as can the drums, and drum drive motors.

The skyline runs through the centre of the tower to a sheave on a pivoting bracket at the top. Another sheave mounted to the rear of this bracket supports the main rear guyline. The mainrope also feeds up through the tower, but it emerges from a pivoting sheave in a notched aperture, approximately two feet from the tower top. The tailrope, strawline and the other two rear support guys pass through sheaves, mounted in brackets near the top of the tower. The two front check guys are fixed to brackets.

To operate the hauler, the operator selects the drum to be driven and the direction required, by turning one of four selectors on the control panel. This activates the solenoid attached to the appropriate directional flow valve which opens the oil passage to the selected drum motor. Once this is done oil from the pump can be directed through the system to drive the motor.

2.2 Lotus Series II Specifications

Carrier Unit		Leyland Albion 6 x 4 Truck
Hauler Engine -	Type	VM Diesel, Model T 1056 SU
	No of cylinders	6
	Power	89.5 k.w. (120 hp)
	Maximum R.P.M.	2800
Transmission -	Hydraulic Pump	Lucas variable displacement Axial piston type, 1/1 ratio.
Drum Drives -	Skyline	Lucas B200 radial piston motor
	Mainline	Lucas B200 radial piston motor
	Tailrope	Lucas B200 radial piston motor
	Strawline	Lucas B030 radial piston motor
Drum Capacities -	Skyline	762 metres, 6x31, 19 mm wire rope
	Mainline	762 metres, 6x31, 13 mm wire rope
	Tailrope	1554 metres, 6x31, 13 mm wire rope
	Strawline	332 metres, 6 mm wire rope
Tower		13.0 metre, tapered box steel Construction. Tower hinged for Transport.
Lateral Stabilisers		Four, rear mounted hydraulic stabilisers, individual control
Guylines		Three rear guys, drum mounted, manually operated. Two front guys fixed.
Hydraulic Tank Capacity		727 litres
Fuel Tank Capacity		30 litres
Fuel Usage		3.76 litres/hour

NOTE: This specification is for the machine owned by - Forest Industries Company Ltd., JAMAICA.

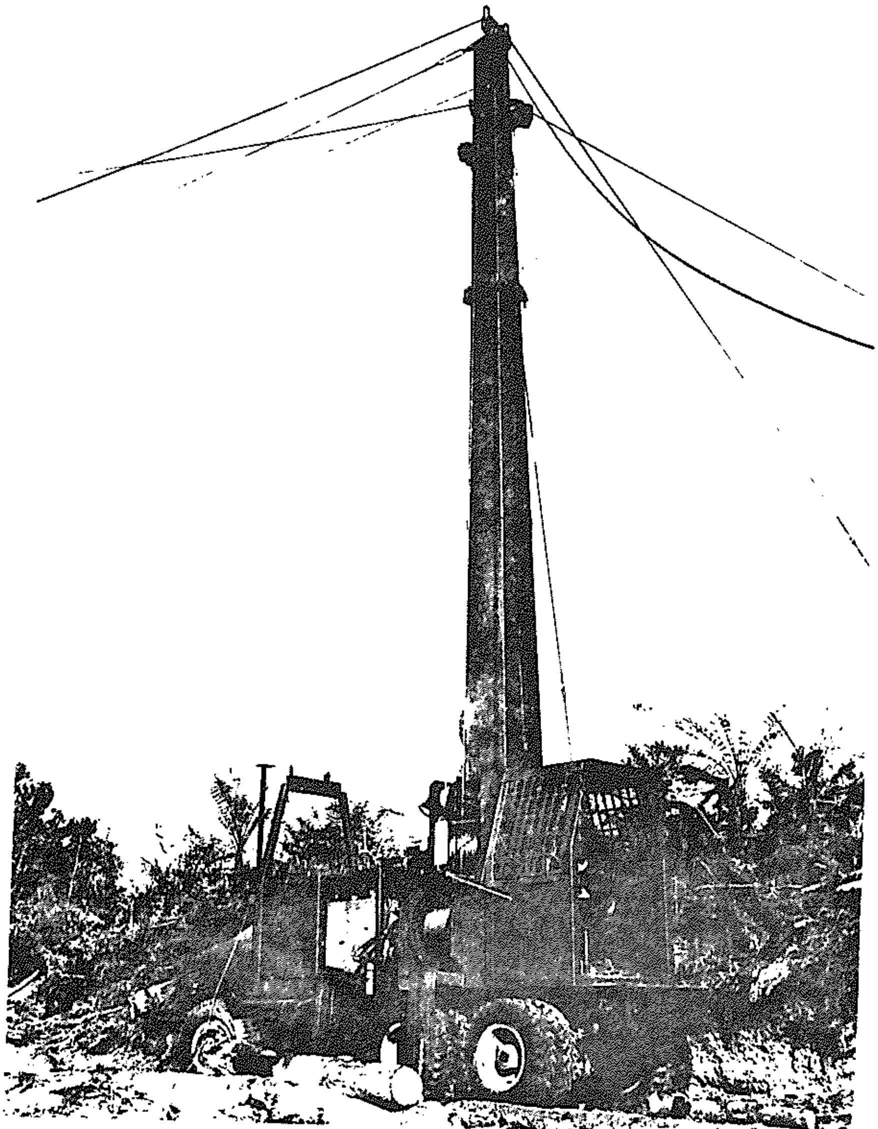
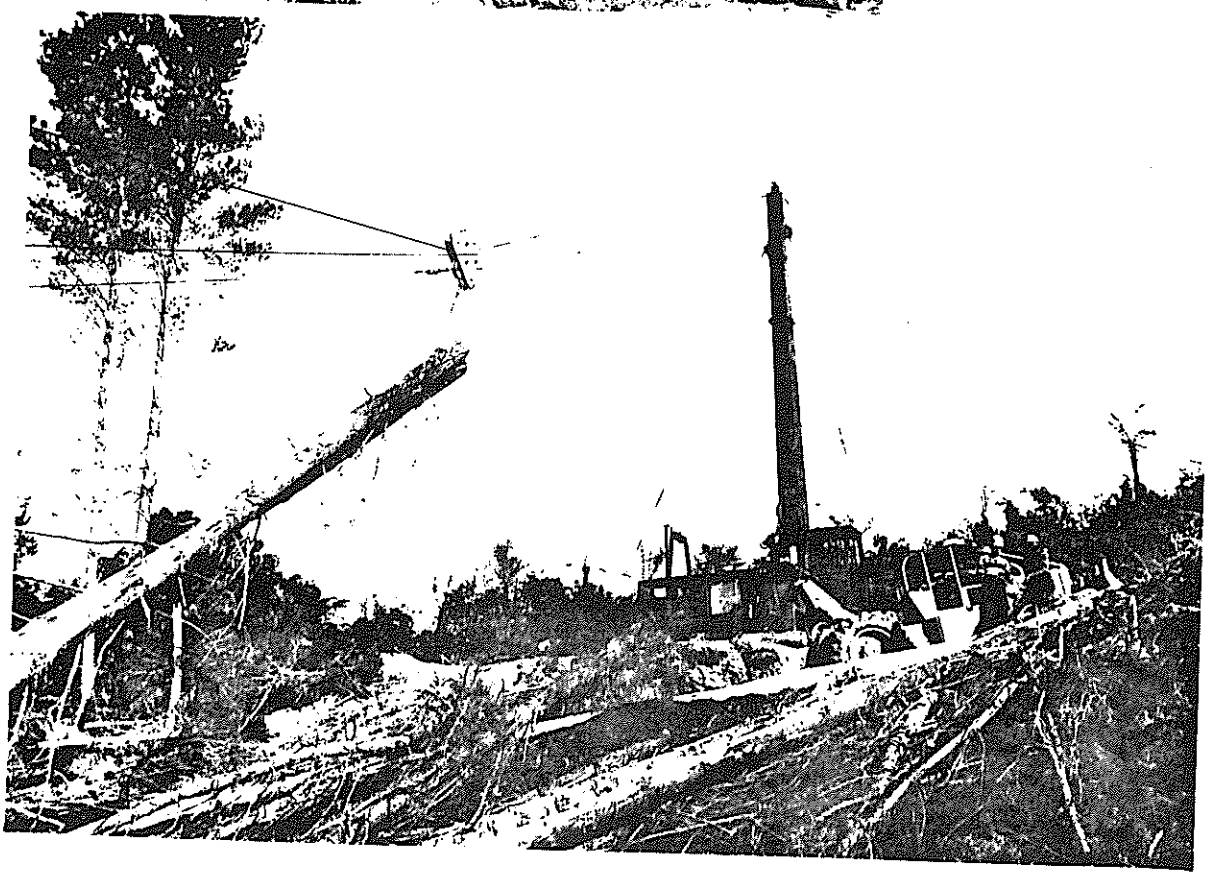


PHOTO 1

Lotus Series II Hauler



2.3 MACHINE DESCRIPTION

2.3.01 Carrier Unit

The carrier unit, a Leyland Albion 6 x 4 truck, is a flexible chassis ex-concrete truck, modified to carry the hauler. It has a 132 hp engine driving through a 8-speed gearbox. The truck is 6.86 metres long, and 2.36 metres wide, and 2.33 metres high at the cab. The original cab has been removed and a half cab built in its place. Access is gained through a door on the righthand side. The cab is glazed on all four sides, although none of the windows open. The truck has air-brakes with a mechanical handbrake, and was fitted with 9 x 20 retreaded tyres when delivered.

Note: The carrier unit described above was specified by FIDCO and is not standard equipment.

2.3.02 Hauler Engine

A naturally asperated six cylinder VM diesel powers the hauler. It is a four-stroke direct injection engine, delivering 89 kW (120 hp) at 2800 rpm (maximum). The engine has cast iron heads with alloy pistons, is air-cooled by an axial blower and has an automatic centrifugal governer. There is an adaptation to drive a hydraulic pump from the crankshaft axle at the front of the engine, and this is used to power the ancillary hydraulic circuit. The VM engine comes complete with a 30 litre fuel tank.

2.3.03 Hydraulic Pump

The hydraulic pump is a commercial Shearing HD2-4000 series axial piston pump. The pump has a displacement of 303 cc's per revolution, giving it a flow rate ot 303 litres per minute at 1000 rpm. It has a maximum rated speed of 2,500 rpm and can generate up to 4,500 psi. The HD2-4000 is 460 mm long and mounts directly onto the rear of the hauler engine. A 49 mm shaft connects the pump to the engine drive through a splined coupling.

2.3.04 Hydraulic Motors

The main, tail, and skyline drums are all driven by B200 Staffa hydraulic motors. These motors are radial piston type, with five cylinders equally spaced around an eccentric crankshaft. Each motor displaces 3.08 litres per revolution, and has a maximum inlet pressure of 4,250 psi. Approximately 93 kW can be generated at a maximum continuous speed of 175 rpm. Dimensionally, the motor is 438 mm long, 648 mm wide, and weighs 283 kg dry. Coupling to the drums is through a splined shaft.

The B030 Staffa motor driving the strawline is of similar construction to the B200 motors. Its displacement volume, however, is .442 litres per revolution, although it still has a maximum inlet pressure of 4,250 psi. A lower 37 kW is available from the B030 at a maximum continuous speed of 450 rpm. It is 275 mm long, 371 mm wide, and weighs 73 kg.

2.3.05 Drum Set

All drums are constructed of MS plate. They are driven through splined connections to the drum motors, and rotate on pillow-block bearings.

2.3.051 Skyline Drum

The skyline drum is made of 12 mm plate steel and is mounted on the right-hand side of the machine. It has a barrel diameter of 203.2 mm, a flange depth of 850.9 mm, with an inside drum width of 514.35 mm. The drum incorporates a narrow 110 mm wide split drum to enable increased purchase for tensioning the skyline. The attachment slot for the skyline rope ferrule is between the two portions of the drum. To enable the rope to fleet properly, the drum is positioned so that the inside edge of the drum barrel is under the bottom of the tower, consequently the skyline drum is under-wound.

2.3.052 **Mainrope Drum**

The mainrope drum is made of 12 mm plate steel and mounted at the base of the tower on the left-hand side of the machine. It has a barrel diameter of 279.4 mm, a flange depth of 609.6 mm, with an inside drum width of 508 mm. Again, the inside edge of the drum barrel is beneath the tower to enable proper fleeting. The mainrope drum is also under-wound.

2.3.053 **Tailrope Drum**

Immediately below the mainrope drum is the tailrope drum, which is constructed of 12 mm plate steel. It has a barrel diameter of 203.2 mm, a flange depth of 812.8 mm, with an inside drum width of 508 mm. This drum is over-wound, and the rope passes up through a sheave 1.3 m from the top of the tower (refer 2.2.08).

2.3.054 **Strawline Drum**

The 12 mm plate steel strawline drum is mounted above the mainrope drum, and is under-wound. It has a barrel diameter of 167.6 mm, a flange depth of 373.8 mm, with an inside drum width of 167.9 mm. The strawline sheave is positioned 0.42 m below the tailrope sheave (refer 2.2.08).

2.3.055 **Guyline Drums**

The rear guyline drums are all hand wound, requiring a 32 mm socket, or similar spanner to operate. All drums have a barrel diameter of 120 mm, a flange depth of 250 mm, with an inside drum width of 190 mm. The three drums are mounted in brackets immediately above the skyline drum. Rope attachment to the drums is by a 5 mm bolted latch.

2.3.06 **Hauler Frame**

The hauler frame is constructed of 12 mm plate, mounted on 4 x 150 mm channel steel sections. It is 1.95 metres high, and 1.90 metres across. The width of the drum frame is .83 metres, and it is strengthened by internal gussets. Total height of the unit, mounted on the carrier with the tower folded down, is 3.89 metres. Two hardwood runners provide insulation between the truck chassis and the hauler frame.

2.3.07 **Controls**

The controls are a combination of electric over hydraulic (except for the pump "stroke" control), and are all mounted on the control panel in the cab. Square D electric selectors control which drum is to be used and the direction to be driven in. These operate solenoids which activate the appropriate directional flow valves. On/off switches are used to enable freewheeling on the main and tailrope drums, while push-button releases control the freewheeling of the skyline and strawline. Control of the pump is through an OCR Rexroth pressure related joy-stick. This means that the further the joy-stick is moved into "stroke" the higher the volume of oil generated by the pump. The pressure gauges show the hydraulic pressure in the three main working drum circuits during operation. The tailrope brake is a wheel-valve type, which restricts the flow of oil from the tail rope motor, building up back pressure to give effective braking. Therefore, the further the valve is screwed in the higher the tailrope braking available. The four lateral stabiliser legs are lowered and raised by a four-way selector, and two associated buttons, one for down, the other for up. Control for the hydraulic ram for raising the tower is mounted on the right-hand side of the machine next to the skyline motor. Throttle control is through a push-pull cable, mounted on the hauler frame inside the cab.

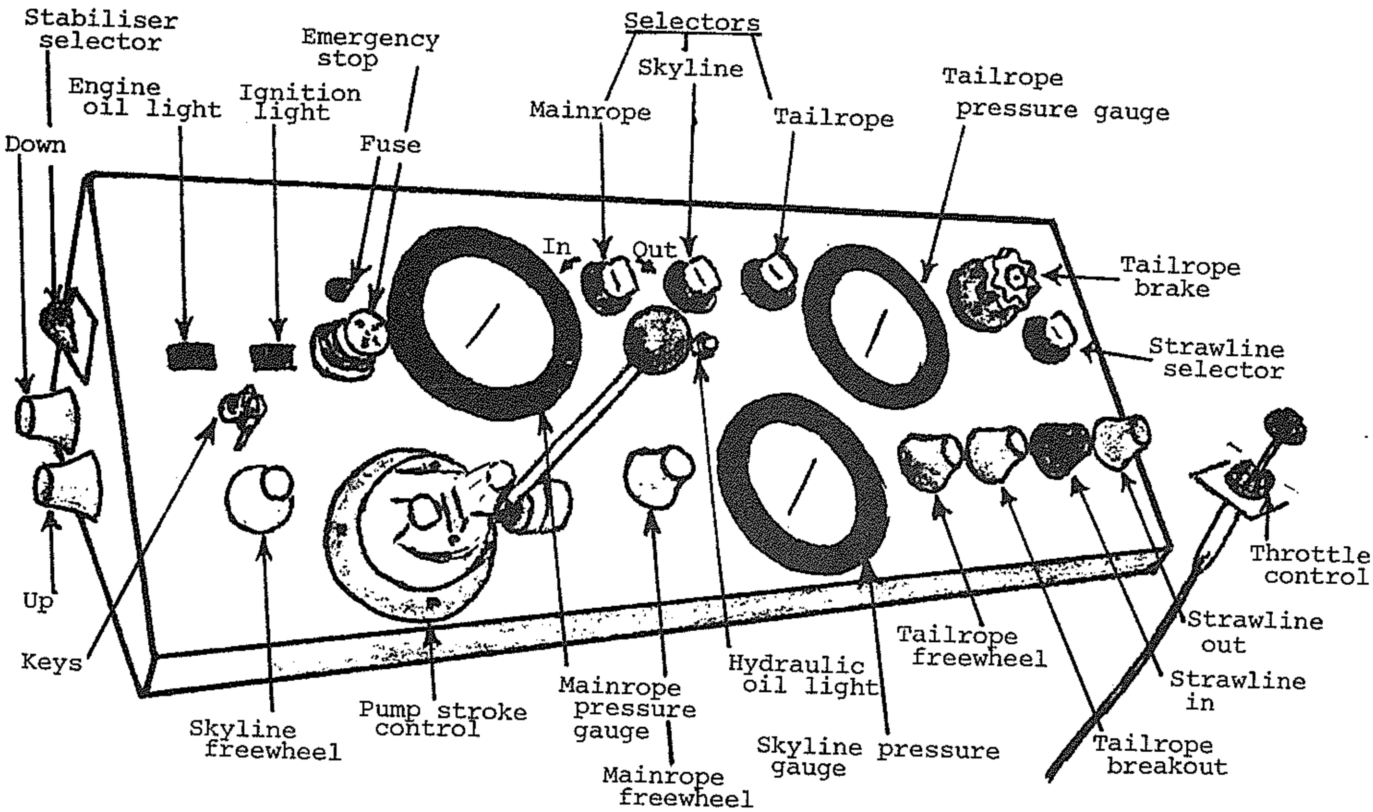


FIG. 1 - Control panel layout

2.3.08 Tower Construction

From the ground to the top of the skyline sheave the Series II is 13.0 m high. The tower itself is 9.25 m high, and constructed of 12 mm plate steel. It is 600 mm x 600 mm at the base and tapers down to 360 mm x 250 mm at the top. A hydraulic ram, mounted on the hauler frame, is used for raising and lowering the tower. At 3.5 m from the top, the tower is hinged and when it is lowered for road transport, this section can be folded back parallel with the bottom section of the tower. Two pins at the base and two at the hinge point hold the tower in position. The sheave layout is shown in Fig.2.

2.3.09 Cab Construction

The cab is constructed of 100 mm x 100 mm box section uprights, tapering in towards the 6 mm plate roof. Interior height is 190 mm, and base width 130 mm. The rear of the cab is open and the sides have 6 mm plate steel panels. Two 100 x 90 mm screens constructed of 19 mm x 19 mm steel, allow vision out either side. A pivoting Bostrum seat is height adjustable for operator comfort. The cab floor is constructed of 6 mm plate, and a step forms an outside platform. Height from the ground to the platform is 1.1 m.

2.3.10 Lateral Stabilisers

The four lateral stabilisers are mounted on horizontally telescoping 130 mm x 130 mm box section beams with hydraulic hoses for the rams passing through the centre. Each stabiliser has two positions, one in close to the carrier unit for travel, and the other 77 mm out from the chassis for operation. The legs are slid in and out manually and are held in position with pins. Lowering and raising the legs is done hydraulically with a switch, and push button combination on the control panel.

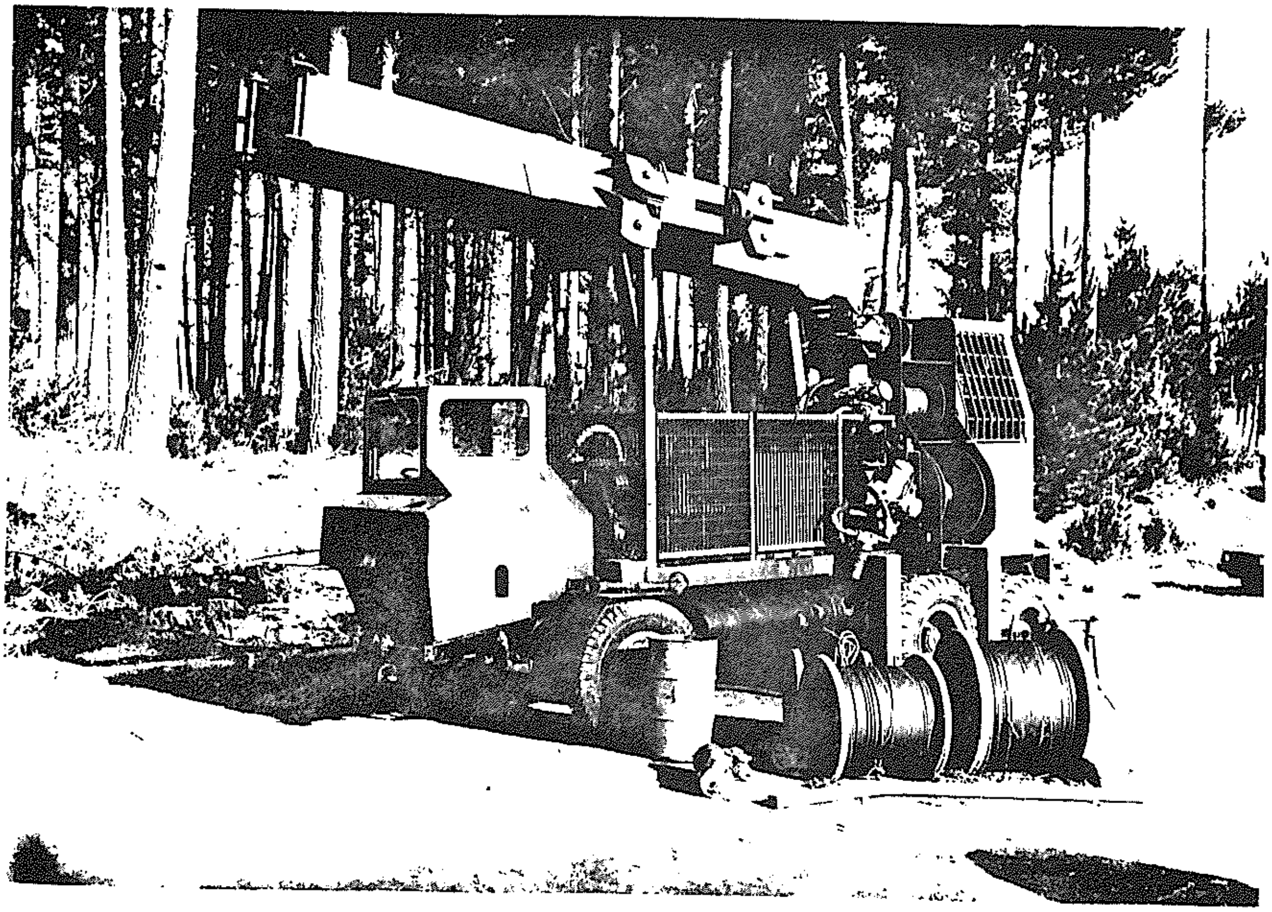


PHOTO 2 - Tower down and folded for travel

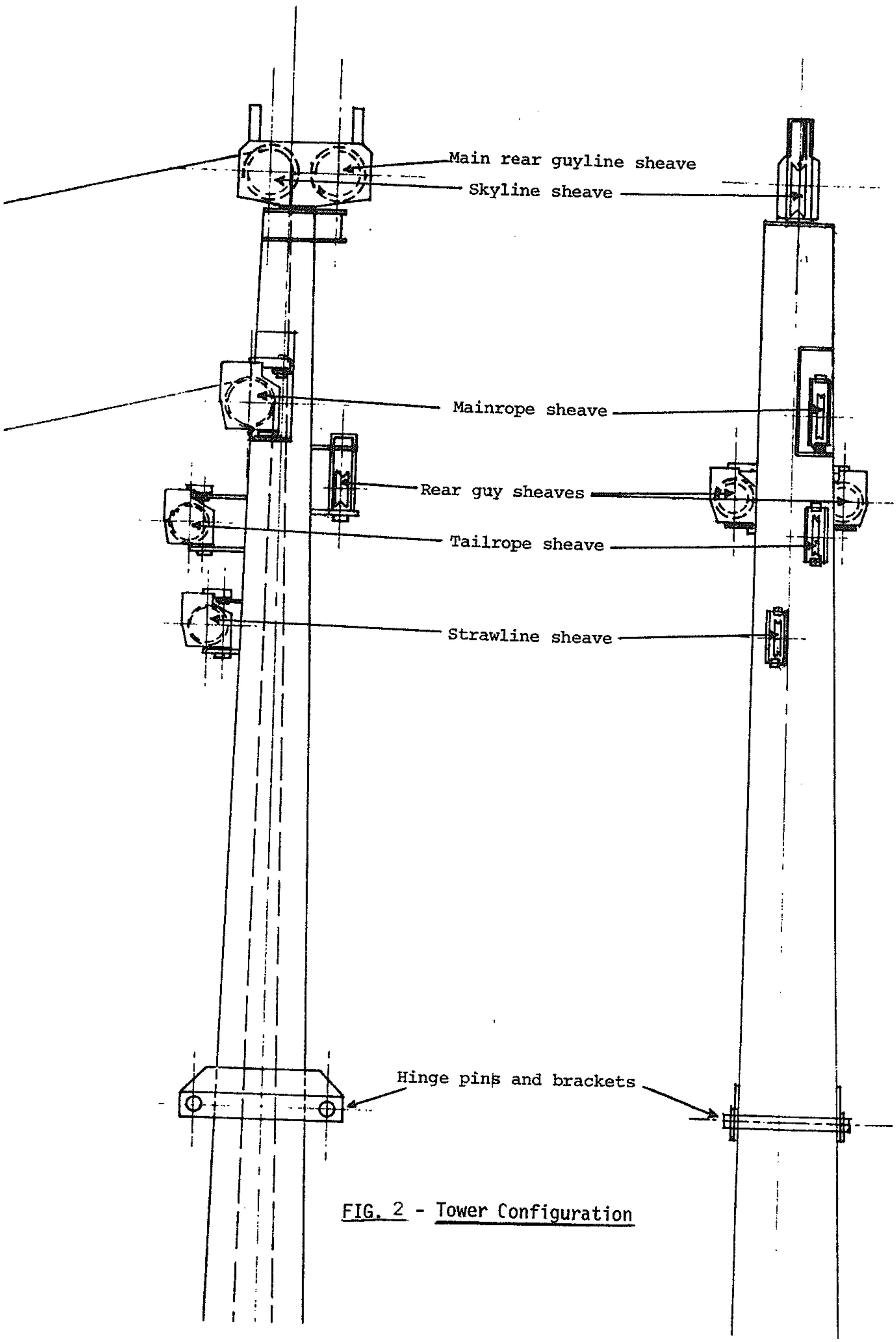


FIG. 2 - Tower Configuration

SECTION 3

OPERATING PRINCIPLES

The modern hydraulic system, as well as being a very efficient method of transmitting power can also separate and combine force and speed. In other words, hydraulic drive can adapt to the shifting requirements of line pull at breakout, and line speed during in-haul, without the need to change gears or alter engine revs. This capacity is graphically illustrated in a print-out from a pengraph recorder plugged into the hydraulic system (refer Fig.3). The high demand for force is shown in tensioning the skyline and breaking out the turn where relief valve settings are reached (refer 3.3). The lower demand for force is reflected in the inhaul cycle, where this power is converted into speed. The outhaul phase of the cycle requires less force again, as the weight of the turn has been removed.

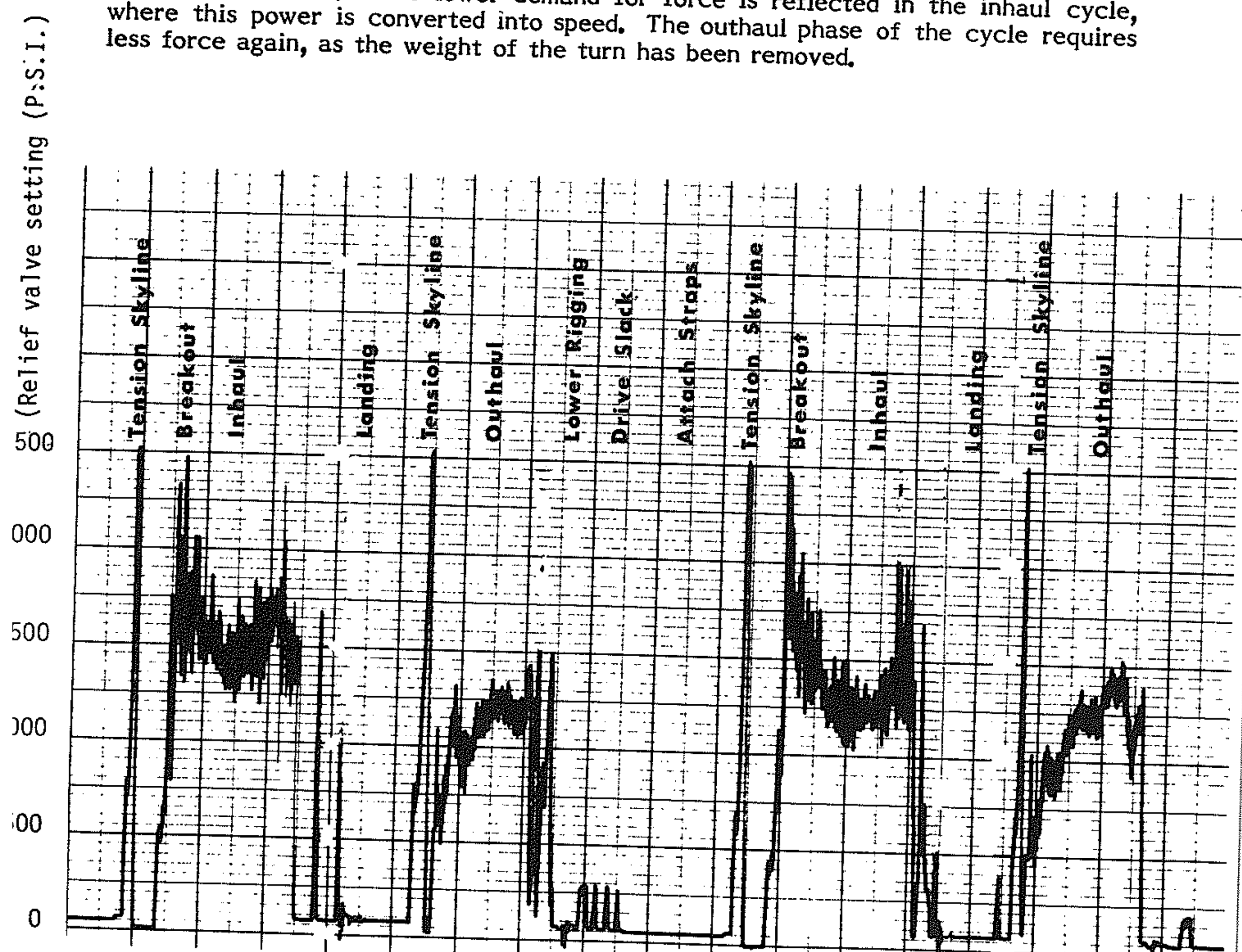


FIG. 3 - Printout of typical Lotus Hauler cycle.

3.1 Pump Operation

To achieve this combination of line pull and line speed, a variable displacement pump is necessary. Variable displacement means that the volume of oil pumped at a certain pressure can be altered according to demand and this is determined by the position of the control lever. Movement of the control lever adjusts the angle of the swash plate on which run multiple pistons, rotating axially on the pump drive shaft. Each piston draws oil into the cylinder through the top of the rotation and forces it out at the outlet port at the bottom of the rotation. As the control lever is moved it operates the pilot piston through the servo piston, which alters the angle of the swash plate, increasing the volume that each piston carries. This means that at a set pressure of say 2,500 psi, full power from the pump is available through an infinite range of speeds, adjusted according to the position of the control lever. So, if the swash plate is in a central position, oil can circulate through the pump with no force being generated. Once the swash plate is on a slight angle, the full 2,500 psi is moving through the circuit at a low rate. As the swash plate angle is increased so to does the volume of oil passing through the circuit, and consequently, the speed of the selected drum.

3.2 Directional Flow Valve

On leaving the pump, the oil passes through hydraulic hoses to a bank of directional flow valves. As mentioned before, these are controlled by solenoids activated by selectors mounted on the control panel. The solenoids simply open the selected valve in the desired direction (refer Appendix 5). If none of the valves are opened, the oil from the pump is simply returned to the reservoir. Once a drum is selected the appropriate solenoid opens the valve and oil from the pump can be diverted through hoses to the drum motor. This only happens though if the pump is on stroke. If the pump isn't on stroke, the motor remains stationary.

3.3 Relief Valves

Oil from the directional flow valves goes through hoses to Rexroth cross-flow relief valves, mounted at the inlet to each motor. These relief valves are a safety measure and can be set according to the safe working load of the rope. They consist of a spring loaded piston in a cylinder mounted above, or to one side, of the main oil flow into the drum motor. When the resistence of the load on the drum reaches the preset relief valve setting the drum stops turning and oil stops circulating. When this happens the piston compresses the spring which is forced up the cylinder to uncover a relief port. The oil is then diverted through this port and back to the reservoir. Once the pressure recedes below the relief valve setting the piston returns and the oil continues on through the drum motor again.

3.4 Drum Motors

From the relief valves oil passes into the individual Staffa motors, through two spiral slot arrangements in the crankshaft. These slots are located beside the appropriate inlet ports according to the direction to be turned. As the crankshaft rotates the spiral moves around to uncover the feed-line to the radial piston at the top of its stroke. As one slot runs out of oil to feed the pistons, the next slot is taking on more oil to continue the momentum. The Staffa motor has an eccentric crankshaft on which ride the five radial pistons mounted on slippers. As oil is fed in from the slot arrangement, each piston in turn forces the eccentric of the crankshaft onto the next one and in doing so produces torque. As the crankshaft continues its rotation the eccentric pushes the piston back up and oil is released through outlet ports, making the piston ready for the next stroke. The used oil is then returned to the reservoir.

Each piston has a hole through its centre to equalise the pressure in the cylinder and provide lubrication for the slippers on the crankshaft. This hole makes the motor easier to rotate when free-wheeling of the drum is required.

SECTION 4

TRIAL OBJECTIVES

To field test, evaluate and report on the Lotus Series II hauler. The trial objectives were twofold.

1. To determine that the hauler satisfied the design and performance specifications as originally agreed between Lotus Enterprises Ltd and their client, Forest Industries Development Company (FIDCO).

2. To field test and assess the hauler's operational performance and productive capability in a production situation.

It was felt that the best way to run the evaluation trial was to put the hauler into an operational situation with a competent contract crew. It was also felt that the specific tests required for FIDCO should be carried out in the same setting as the production trials.

Careful thought was given to which crew to hire as we required one with experience in small haulers, expertise and versatility of individual crew members, and a willingness to try new ideas. The crew hired was one of the best of New Zealand Forest Products contractors, who normally run a Timbermaster hauler in P.radiata thinnings. The evaluation was held in two stages.

4.1 Stage 1 - Machine Certification

To produce the required impartial report requested by FIDCO the following test programme was proposed by LIRA and accepted by Lotus Enterprises Ltd and the nominated FIDCO equipment inspectors, J.G. Groome and Associates.

To ensure that the trials were carried out in an impartial manner, and followed standard engineering practices, Mr R. Slade, a registered engineer from New Zealand Forest Products Garage Division, witnessed the trials and co-signed this report as being a true and accurate report of the test results.

4.2 Test Programme Proposed

4.2.01 General Configuration

A descriptive report will be written about the machine covering aspects that cannot be individually tested.

4.2.02 Safety

The safety features of the machine will be checked to record their compliance with the New Zealand Safety Code.

4.2.03 Drum Capacity

Physical measurements of the individual drum dimensions will be made to calculate both the size range, and capacity of wire rope that can be used on each drum.

4.2.04 Line Speeds

Line speeds at bare, half and full drum will be measured and recorded. The half drum line speed will be certified at a nominated relief valve pressure and input rpm.

4.2.05 Line Pull

A load cell test gauge will be used to determine the line pull of all drums at bare, half and full drum capacity. The half drum line pull will be certified at a nominated relief valve pressure and input rpm.

4.2.06 Braking

A load cell test gauge will be used to test the effective braking capacity of both the main and tail ropes at bare, half and full drum capacity. As the skyline drum has a mechanical lock, the locking pawl will be checked and monitored.

4.2.07 Guylines

Guyline loadings will be tested by using a fully suspended mid-span load of a known weight.

Note: The load cell test gauge used to record line pull, guyline loadings and the braking capacity, was calibrated and certified correct prior to the trials by a firm of Registered Consulting Engineers.

4.3 Stage 2 - Production Trials

As part of the FIDCO machine evaluation tests a production trial was also proposed, time permitting. This was to be 7-10 days and a work study approach would be used to record all operating, stand- by and downtime, cycle times, elements within the cycle, piece size, volume per haul, and total volume.

Depending on area, and the time available, trials would include as many systems, and rigging options, as possible.

SECTION 5

MACHINE CERTIFICATION TESTS

It was not possible to follow the exact trial programme as outlined, due to operational changes dictated by the damage from the Easter storms. Because of this storm the original area proposed for the trial was no longer available and a substitute area was provided, which was unsuitable for some of the tests proposed, so only those sections of the tests requiring certification were completed.

The certification tests were completed under operational conditions and the variance between specification and test was used to calculate the expected performance levels for bare and full drum.

Some additional tests, which were not in the original programme, were also carried out.

5.1 Safety

Because the machine has been built for a specific export order and will not be used in New Zealand, Labour Department safety certification was not possible.

It does, however, comply with both the current and the draft revised safety code for haulers.

Operator protection is excellent, and the guards for protection of the hauler engine, and the hydraulic system, are more than adequate.

5.2 Drum Capacities

The wire rope capacities of each drum were determined for the specified wire rope size, and also for a range of alternative rope sizes.

5.2.01 To determine the drum capacities for the specified wire rope the total length of rope supplied by Cookes Consolidated Services Ltd was wound onto the individual drums. Rope length, diameter and construction was checked against the factory invoice and delivery documents.

The specified wire rope capacity of the individual drums was :

1. Skyline, 2,500 ft of 19 mm
2. Mainline, 2,000 ft of 13 mm
3. Tailrope, 5,100 ft of 13 mm
4. Strawline, 1,088 ft of 6 mm.

From supplier invoices of delivered wire rope the following lengths were put on each drum.

1. Skyline, 2,500 ft of 19 mm, 6 x 31 wire rope (both the storage and split sections of the drum were required for this length of rope).

2. Mainline, 2,500 ft of 13 mm, 6 x 31 wire rope.

3. Tailrope, 5,100 ft of 13 mm, 6 x 31 wire rope.

4. Strawline, 1,000 ft of 6 mm wire rope.

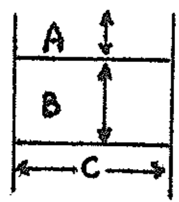
NOTE :

1. If the specified lengths of skyline, mainline and tail rope had been laid on the drum under tension the drum capacity would have been greater.

2. 1,000 ft of strawline was laid on the drum with the balance in detachable 750 ft sections.

5.2.02 The calculated wire rope capacity of each drum for a range of alternative wire rope sizes was determined by measuring the drum barrel, the outer flange and width, then calculated using a standard engineering formula where;

rope length = (a + b) x a x c x rope factor.



The rope factors and alternative rope sizes were :

Rope Size	Rope Factor
11 mm	1.37
16 mm	0.672
22 mm	0.342

Skyline, 22 mm rope capacity : 1,832 ft (558 m)

(12.75 + 8) x 12.75 x 20.25 x .342 = 1,832

Mainline, (a) 11 mm rope capacity : 3,117 ft (950 m)

(11 + 6.5) x 6.5 x 20 x 1.37 = 3,117

(b) 16 mm rope capacity : 1,529 ft (466 m)

(11 + 6.5) x 6.5 x 20 x 0.672 = 1,529

Tailrope, (a) 11 mm rope capacity : 6,576 ft (2004 m)

(12 + 8) x 12 x 20 x 1.37 = 6,576

(b) 16 mm rope capacity : 3,226 ft (983 m)

(12 + 8) x 12 x 20 x 0.672 = 3,226

5.3 Line Speed

The main and tail rope line speed tests were carried out with both the main and tail ropes, as close as possible to mid-drum capacity.

The mid-drum rope capacity was determined through measurement and calculation to ensure that the line speed tests were carried out on a measured section of rope, each side of the mid-drum.

The line speeds were recorded by timing a measured 50 metres of rope over a marked distance, as shown in Fig. 4.

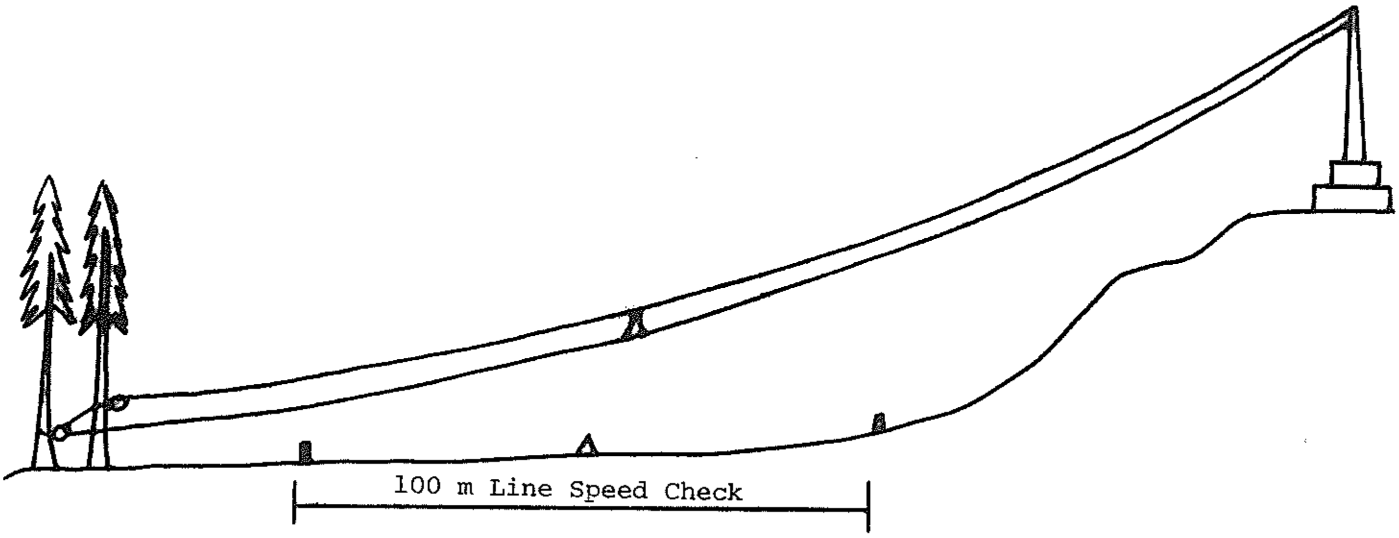


FIG. 4 - Setting for line speed tests

The line speed tests were carried out with the engine governed to 80 horsepower (2,000 rpm), main rope relief valve set at 2,550 psi, and the tail rope relief valve set at 2,800 psi.

As the mid-drum line speed was the only one to be certified, and that it exceeded the specification at the de-rated hp setting, the full and bare drum line speeds were calculated.

The specified, tested, and calculated line speeds are detailed in Table 1.

Line Speed
(feet per minute at 80 H.P.)

	Specification	Test	Calculation
Mainrope -			
Bare drum	204		253
Mid-drum	323	400	
Full drum	408		505
Tailrope -			
Bare drum	153		194
Mid-drum	391	497	
Full drum	544		691

The specified, tested and calculated line speeds from the above Table were plotted on the graph shown in Fig. 5.

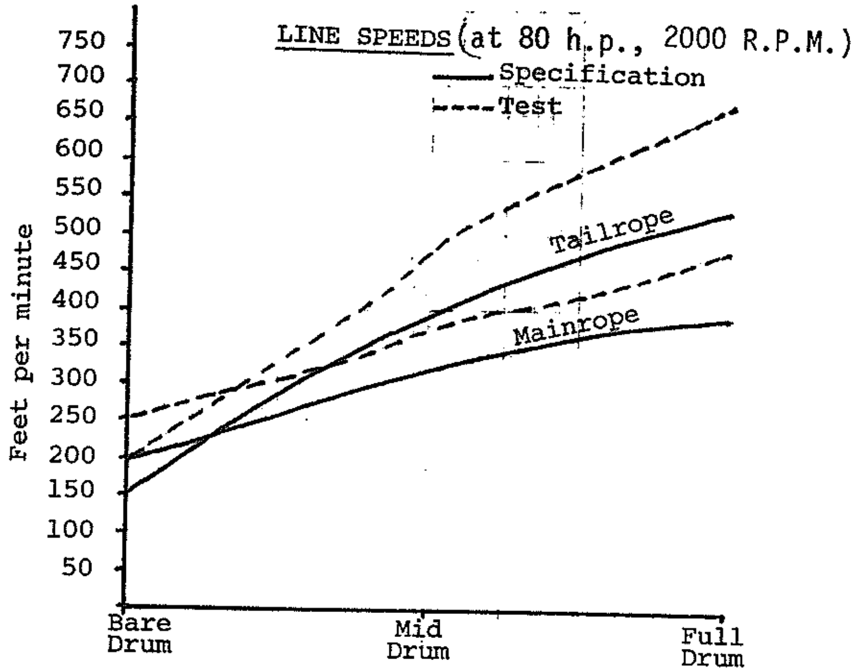


FIG. 5 - Graph of line speed, (80 h.p., 2000 R.P.M.)

It was not possible to measure line speeds at the higher 100 horsepower, 2,500 rpm engine setting, as the engine warranty provisions prevented this, so line speeds were calculated from the variant between specification and test at the lower hp (80 at 2,000 rpm) setting.

The calculated line speeds are as shown in Table 2.

Line Speeds
(feet per minute at 100 H.P.)

	Specification	Calculated
Mainrope -		
Bare drum	267	331
Mid-drum	423	524
Full drum	534	661
Tailrope -		
Bare drum	200	254
Mid-drum	512	651
Full drum	712	905

Both the specified and calculated line speeds at the higher horsepower setting were plotted on the graph, shown in Fig.6.

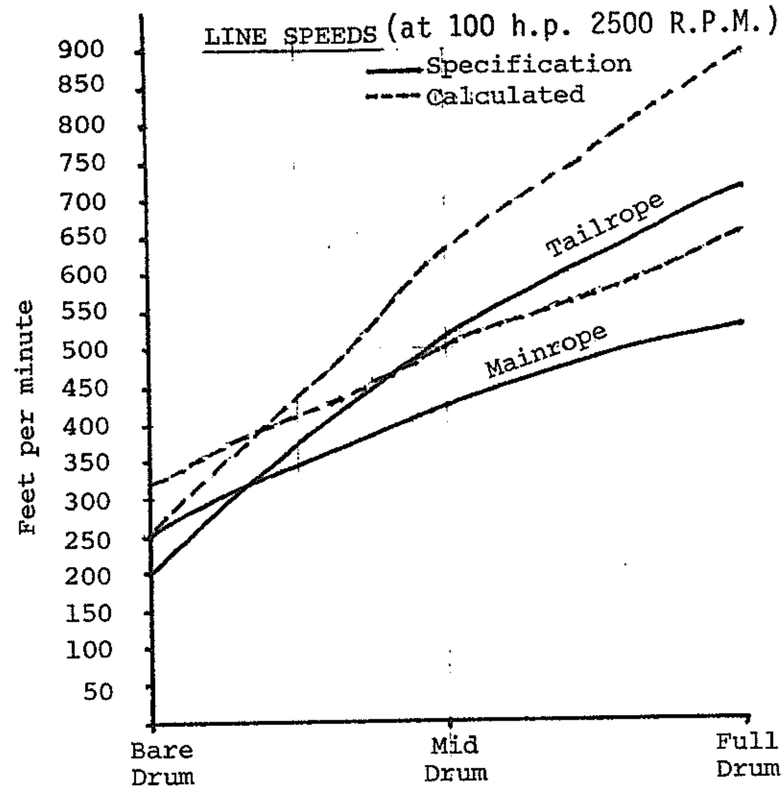


FIG. 6 - Graph of line speeds (100 h.p., 2500 R.P.M.)

5.4 Line Pull

The line pull tests were carried out with the engine governed to 80 hp (2,000 rpm). The main rope relief valve set at 2,550 psi, and the tail rope relief valve set at 2,800 psi.

For both the main, and tail rope, line pull tests, physical measurements were made of both rope length and drum circumference to ensure that the mid-drum level was as accurately defined as possible. The line pulls were recorded by a pengraph recorder, and a digital display unit, which were linked to a load cell test gauge.

The tests were duplicated, so as to record both absolute line pull, and the relief valve setting of the individual drums. The pengraph recorder was a two pen "Yew" Model 3057 which recorded both line pull and the relief valve pressure setting.

5.4.01 Mainline Line Pull Test

The load cell was shackled to a stump at a sufficient distance from the hauler to ensure that the mainline line pull would be as close as possible to mid-drum. Mainline mid-drum diameter is at 19.0 inches, and the tests were carried out with a drum diameter of 19.036 inches.

The mainline, pengraph recorder, and digitai display unit, were linked to the load cell by an electric cable and under no load the pengraph and digital unit were calibrated to zero.

Six line pulls were carried out with the following result :

1. 3.34t	4. 3.41t
2. 3.41t	5. 3.44t
3. 3.38t	6. 3.45t

Average line pull reading - <u>3.405t</u>

Specified line pull - <u>3.38t</u>

The line pull tests were repeated, but with the pengraph recorder plugged into the maindrum drive motor, to determine the mainline relief valve pressure setting. The pengraph recorder print-out for both line pull, and the relief valve pressure setting for the mainline, are shown in Figs.7 and 8 .

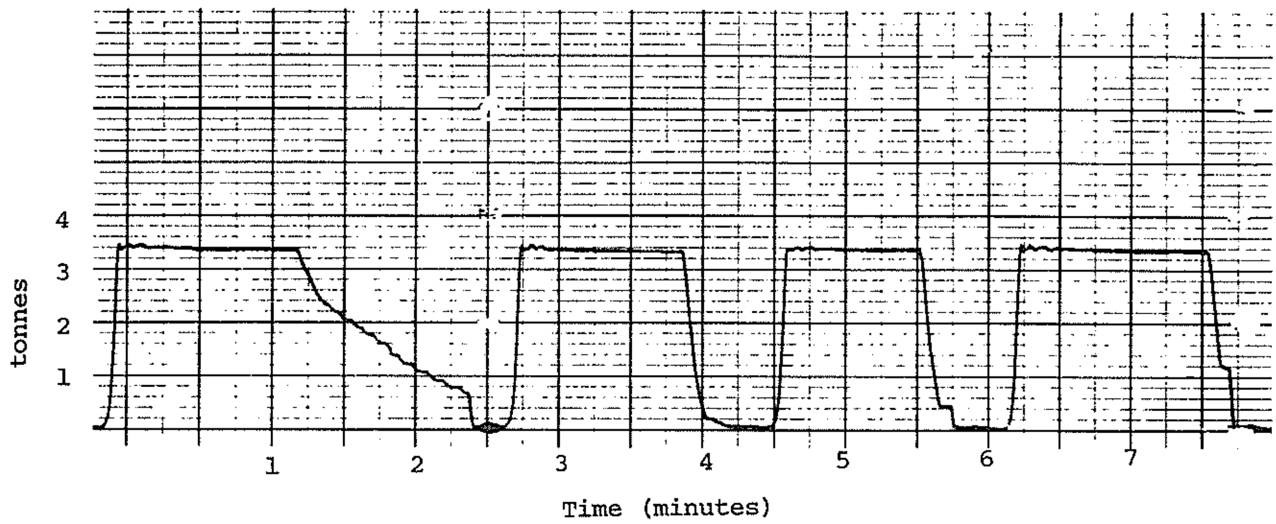


Figure 7 - Mainline Line Pull Test

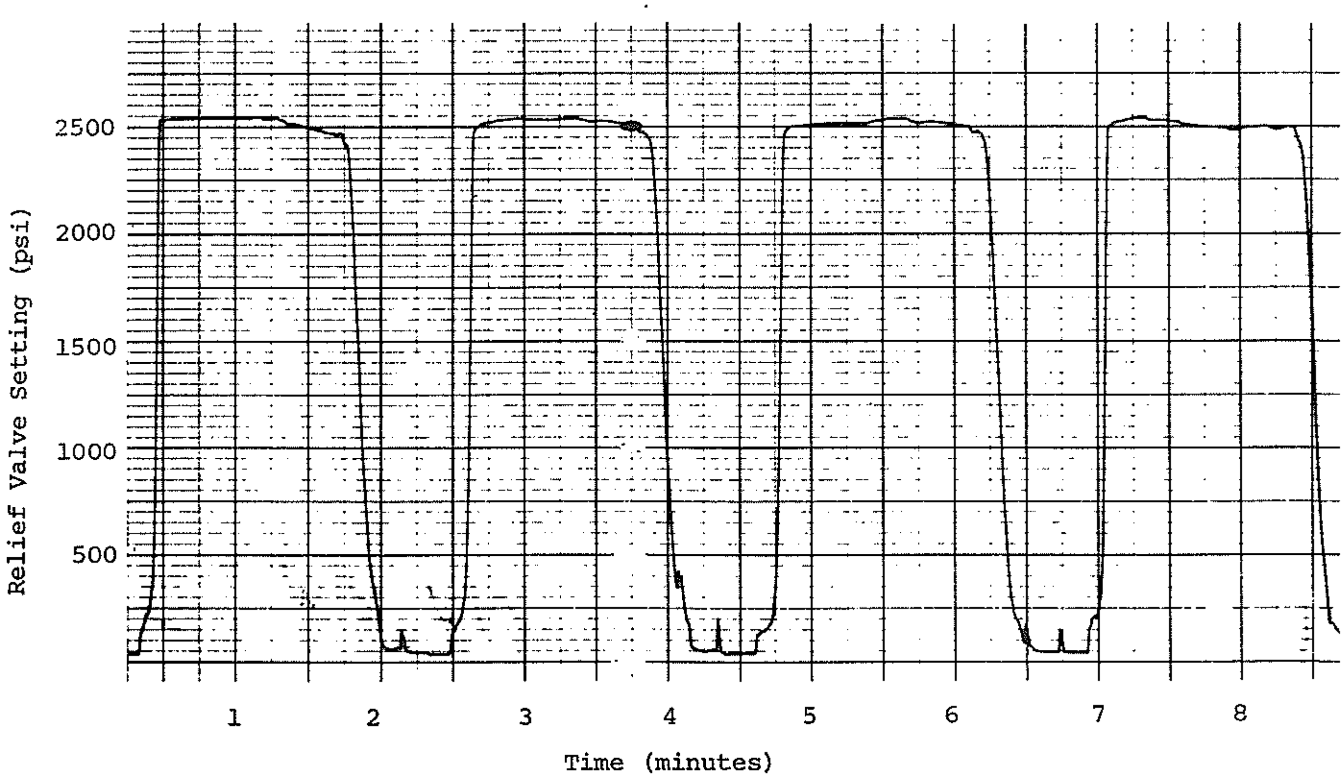


Figure 8 - Relief Valve Setting for Mainline Line Pull Test

5.4.02 Tailrope Line Pull Test

The same procedure was followed for the tailrope line pull tests to determine both the line pull and relief valve pressure setting.

Tailrope mid-drum diameter is 23.0 inches, and the tests were carried out at a mid-drum diameter of 23.25 inches.

Six line pulls were carried out with the following results :

1. 2.74t
2. 2.80t
3. 2.74t
4. 2.90t
5. 2.82t
6. 2.84t

Average line pull reading - <u>2.806t</u>

Specified line pull - <u>2.79t</u>

The pengraph recorder print-out for both line pull, and the relief valve pressure setting for the tailrope, are as shown in Figs. 9 and 10.

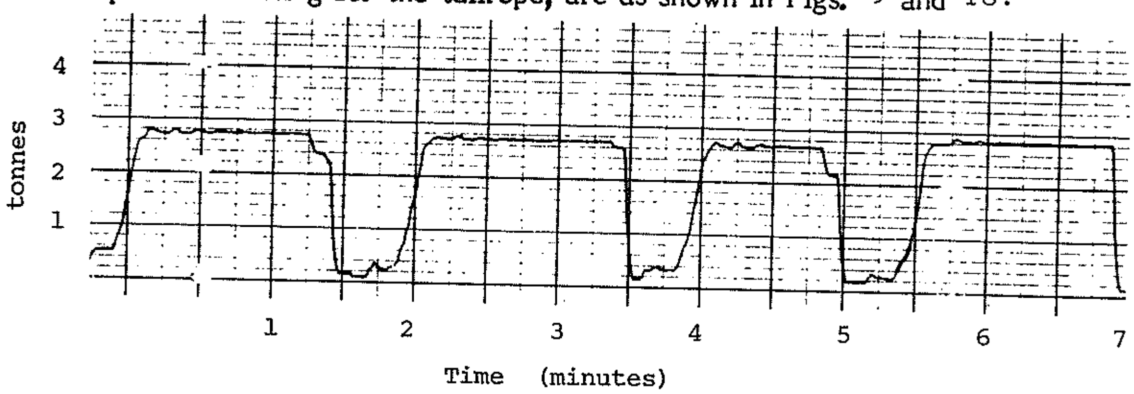


Figure 9 - Tailrope Line Pull Test

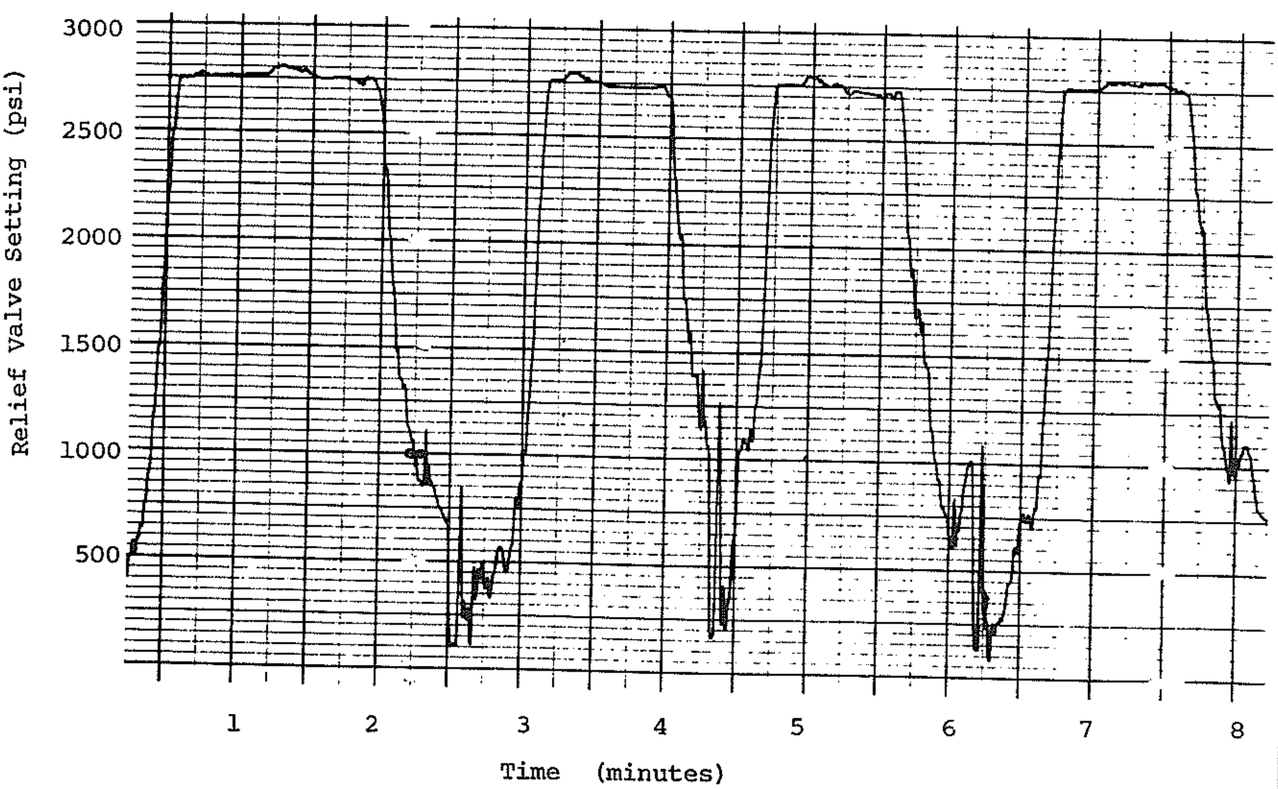


Figure 10 - Relief Valve Setting for Tailrope Line Pull Test

Summary

A summary of the line pull test is outlined in Table 3, and is graphically illustrated in Fig. 11.

As the mid-drum line pull was the only one to be certified, and that it exceeded the specifications, the full and bare drum line pulls were calculated.

Line Pull (tonnes)

	Specification	Test	Calculated	Relief Valve psi setting
Mainline -				
Bare drum	5.357		5.396	2,550
Mid-drum	3.38	3.405		2,550
Full drum	2.67		2.689	2,550
Tailrope -				
Bare drum	6.42		6.445	2,800
Mid-drum	2.795	2,806		2,800
Full drum	2.0		2.01	2,800

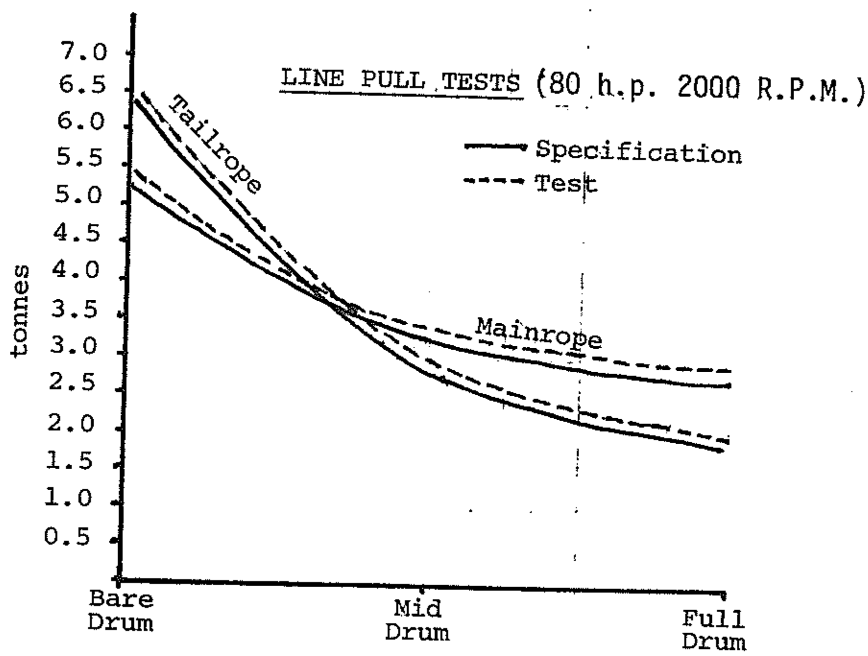


FIG. 11 - Graph of line pull tests

An increase in the 80 hp, 2,000 rpm, test figure to 100 hp, 2,500 rpm, would not change the line pull figures unless the relief valve settings were changed.

5.5 Braking Capacity

5.5.01 Main and Tail Rope

The effective braking capacity of both the main and tail ropes was tested at mid-drum, by a load cell test gauge, which recorded the effort exerted on the individual drums prior to any slippage.

By pulling against the tailrope with the mainrope, the braking capacity of the tail rope was recorded at 3.42t (close to the maximum line pull of the mainrope). The main rope braking capacity was tested up to 2.82 tonne. This figure was determined by pulling the tailrope against the mainrope (close to the maximum line pull of the tailrope).

5.5.02 Skyline

The skyline has a dual braking capability through the relief valve and a mechanical locking pawl.

5.5.021 Relief Valve

The relief valve was set at one-third of the safe working load of 19 mm rope, which was the skyline being used. Under excessive loads the relief valve gradually slips the tension until the relief valve setting is reached, then holds. No difficulty, or problem, was encountered with this feature.

5.5.022 Mechanical Lock

The mechanical lock is a pawl which seats into a gear wheel welded onto the side of the split drum. When the skyline is tensioned, the pawl is seated into the gear wheel manually. To release it, the skyline is re-tensioned, which kicks the pawl out of the gear. During the trials there were no problems with this mechanical lock, although it was found that if the skyline is mechanically locked under maximum tension the pawl is difficult to release.

An important point to emphasise is that the mechanical lock will over-ride the relief valve, which eliminates the safety factor.

With the mechanical lock the skyline is held in tension, regardless of the force imposed, so when excessive loadings occur, damage or rope breakage, will result. The relief valve reduces this danger by slipping excess force.

"Under normal operating conditions use of the mechanical lock is not necessary, and cannot be recommended."

5.5.03 Drum Free-Wheeling

All drums will drive in, drive slack and free-wheel. The slack driving ability of all drums is good, with an operator controlled variable drum speed capability. The free-wheel ability of all drums is also satisfactory.

Because the slack driving, and to a lesser extent the free-wheel, ability of all drums was so good the strawline was not used for line shifts in the trial setting, as it was just as easy to drive slack on the main and tail ropes. The ease of both driving and pulling slack in the mainline, even over 200 metre spans, meant that a greater volume of timber could be pulled from each skyline road, with a corresponding decrease in the number of line shifts per setting.

5.6 Guyline Loading

A load cell test gauge linked to a pengraph recorder was used to record the force exerted on the centre rear guyline over a complete cycle, with a log of a known weight.

The centre rear guy was set to directly oppose the line of pull and a log of 1.17 tonnes was broken out, and hauled in. The turn was stopped, fully suspended, at mid-span, to record the effort exerted on the guy with a suspended static load.

With the guyline tensioned, and all running lines slack, a force of 0.35 tonnes was exerted on the guy. Tensioning the skyline increased the force to 2.23 tonnes momentarily before dropping back to 0.91 tonnes during outhaul.

A maximum guyline load of 4.34 tonnes during inhaul was recorded at mid-span, but this dropped back to 1.69 tonnes with the turn stopped and the log suspended.

At no time during the cycle did the force exerted on the centre rear guy exceed the safe working load of the guyline.

A printout of the cycle is shown in Fig. 12.

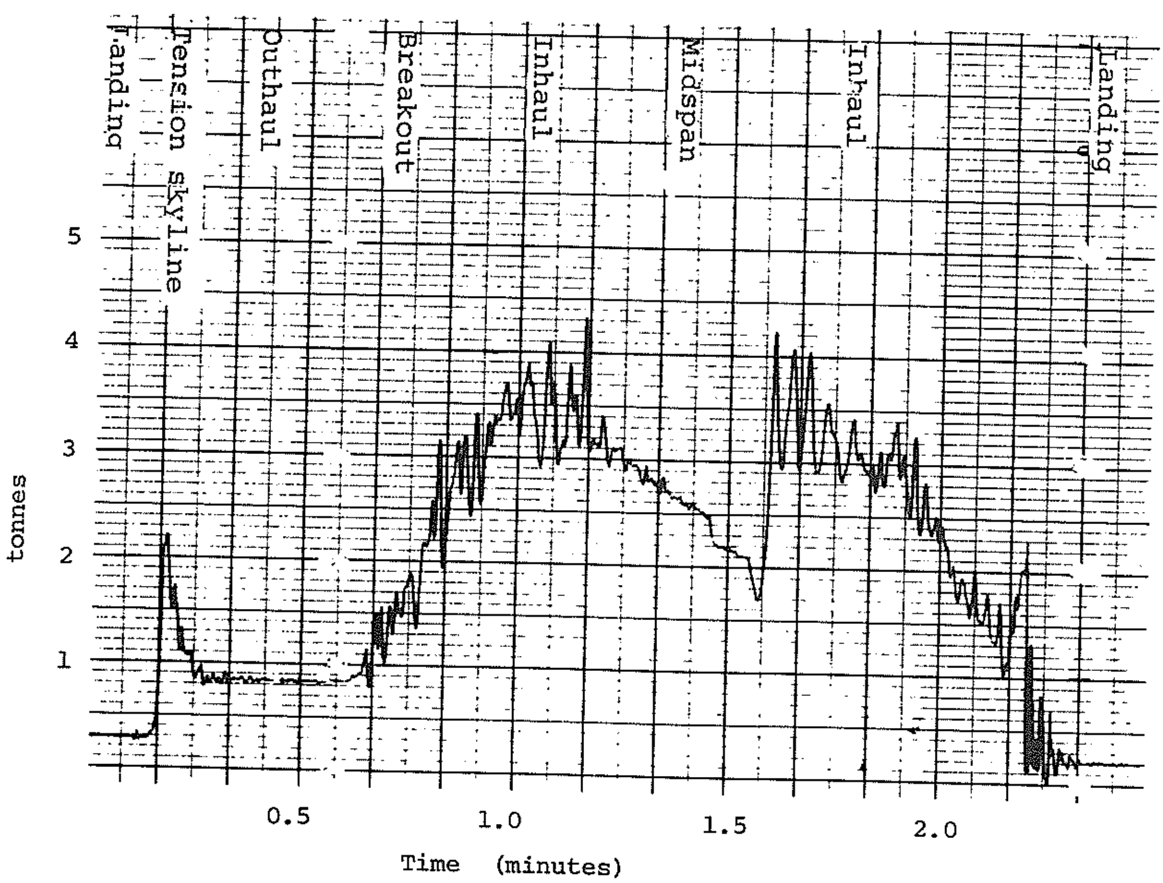


Figure 12 - Guyline Loading Print-out

5.7 Guyline Drums

The guyline drums were checked and tested to determine the ease of guyline tensioning, and the ability of the drums to hold tension.

The three back guyline drums are mounted on the rear of the tower, with the guylines running up the back of the tower and out through sheaves. The centre rear guyline sheave is mounted at the top of the tower, in the same bracket as the skyline sheave, so that the centre rear guy will oppose the line of pull providing the rear guy is rigged accordingly. The two rear side guyline sheaves are mounted on brackets which are fitted to each side of the tower (refer Fig2). For guyline tensioning the drums are fitted with a ratchet which is turned by a spanner and a locking pawl holds the drum in position to retain tension. It was somewhat awkward to tension the guylines in this way. When sufficient guyline tension is achieved, a bolt is used to lock the drum to the drum housing.

There are only two final lock positions on the guyline drum and it was sometimes difficult to line the holes up. Once tightened, guyline tension was constant, as the drum and drum housing are bolted together.

The guyline drum barrel, although adequate for the job, was considered to be too small in diameter to get the best lay ot rope on the drum.

The guyline anchor points on the drum were not particularly robust.

5.8 Operating Temperature

During the production study, recordings of the ambient air temperature, and the operating temperatures of the main drum drive motor, tail rope drum drive motor, hydraulic oil tank, and hydraulic oil cooler, were taken at one hour intervals for one day, using an electronic temperature recorder. All temperature recordings are in degrees centigrade.

These temperature recordings are outlined in Table 4.

Temperature Recordings (°C)

Time	7.30	8.30	9.30	10.30	11.30	12.30	1.30	2.30	3.30
Air Temperature	6	7	8	7	8	10	12	12	8
Maindrum motor									
Piston housing	11	16	14	14	25	18		19	21
Body	12	20	19	15	27	22		24	22
Tail drum motor							Line shift and lunch break		
Piston housing	7	17	18	14	23	20		19	20
Body	7	15	22	15	21	27		23	22
Hydraulic oil,									
Tank oil temp*						30		30	30
Tank body	6	16	20	21	25	22		23	25
Hydraulic oil cooler	6	16	18	8	23	12		22	15

* The hydraulic oil temperature was taken from the gauge on the tank. From 7.30-11.30 the temperature reading was too low to register on the gauge.

During the production trials the operating temperature of the engine and all major hydraulic components did not exceed the manufacturers recommended operating range of -20°C to 65°C.

5.9 Carrier Unit

The hauler is mounted on a used Leyland Albion 6 x 4 truck, with a modified cab, which allows the hinged tower to be folded back and carried parallel to the truck chassis.

With the tower hinged, and in the carry position, the unit was tested for manoeuvrability, traction, stability and climbing ability.

A heavily rutted adverse grade of 30% (16°) with a camber of 13% (7°) was used for the climbing ability test, and stability was tested on an adverse climbing corner of 20% (11°) with a camber of 16% (9°).

In low gear the unit had no difficulty in negotiating this grade, and showed little sign of instability on the corner. Traction in the loose pumice soils of the area was satisfactory, as was the manoeuvrability of the unit around the landing. Some minor problems were encountered on uneven ground through the flexibility of the truck suspension.

SECTION 6

PRODUCTION TRIAL

Originally, the production trial was to be held in a New Zealand Forest Products stand of P.muricata, approximately the same size as the Jamaican P.caribaea. It was envisaged that within the time available as many rigging systems as possible would be tried to establish the versatility of the hauler and to give an indication of the variety of system options that could be used with the machine.

As a result of the Easter storms, plans had to be changed, and a block of partially windthrown P.radiata in Tasman Central's Tauhara Forest was used instead. This block imposed several restrictions on how the hauler could be set up, as follows :

(a) The area had a convex slope of approximately 16% which meant that tail spars had to be rigged to get sufficient deflection.

(b) The trees were both uprooted and broken off which made extraction difficult.

(c) The prescription for salvaging the block called for restraint in felling any standing trees.

(d) Because of the windthrow most guyline stumps were either loose, or partially uprooted, which made it difficult to anchor the hauler securely.

It must be remembered that these conditions, along with other associated supply problems, substantially limited the options open to fully test the machine. As a consequence only two systems were tried. A north-bend skyline, and a simple live skyline, as used on the thinning haulers.

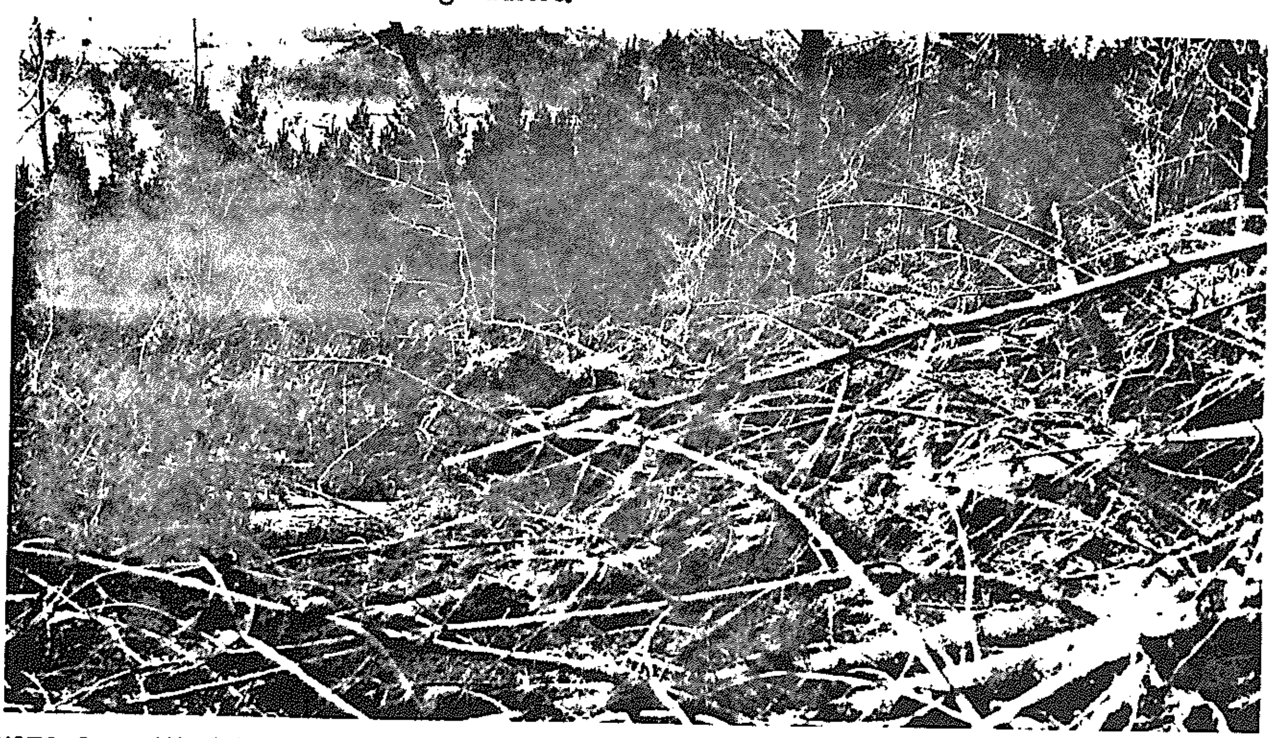


PHOTO 3 - Windthrow in Trial Setting

6.1 Machine Set-up

The hauler was set up in Tauhara on Friday 9th July 1982 to begin initial shakedown trials prior to the field tests being done. This gave New Zealand Forest Products contractor Keith Travers (who was hired to operate the machine for the duration of the trials) a chance to get used to the machine and iron out any problems that may have occurred. On Monday, 26th July, the FIDCO tests (ref. 5/0 and 6/0) were conducted, and these occupied the hauler and crew, on and off, for the next 2½ days. The hauler was originally set up as a north-bend, but this was soon modified to a live skyline when slack pulling was found to be so easy.

The hauler was located on a narrow bench pushed in by a skidder. It was uphill pulling untrimmed trees to a road immediately below the bench, which allowed the skidder access to haul the trees away to the landing for processing. A six man crew operated the hauler during the trials, and this included sorting and fleeting work on the landing. Two men were normally involved with breaking out, although there was a high content of additional chainsaw work necessary, which often occupied one of the pair. During the trial the main rear guy was anchored to a skidder because of the lack of solid stumps, and the tail rope was set behind the haul lines to minimise binding problems.

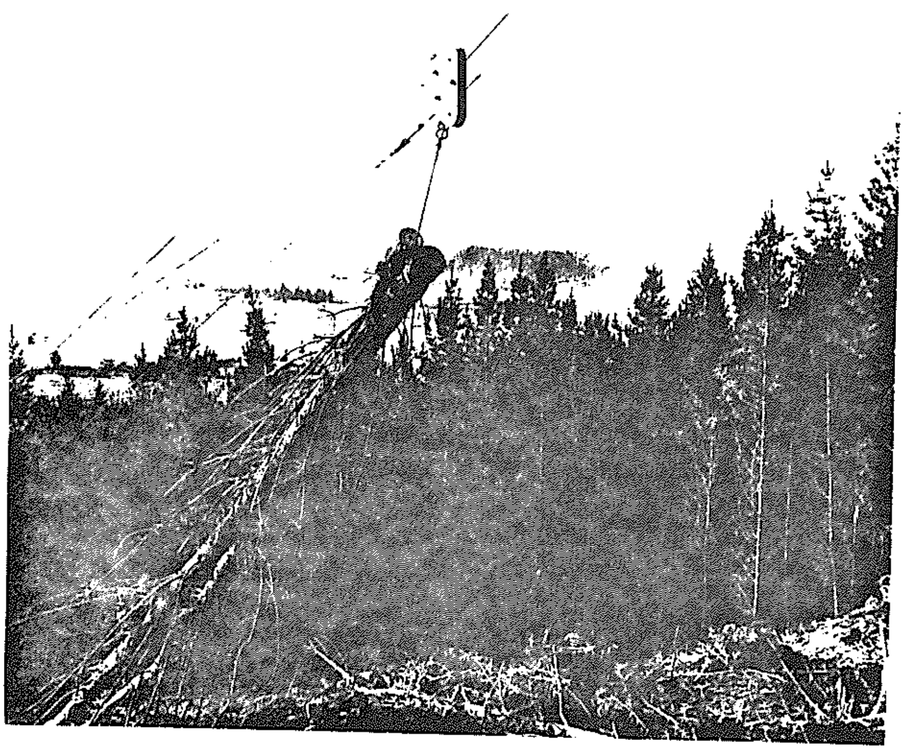


PHOTO 4 - Skyline Road in Trial Setting

6.2 Trial Description

The production trial lasted two days and covered 111 turns. Two haul roads of 176 metres, and 166 metres, respectively, were logged during the study period, which included one line shift (a ground profile run between the two settings is shown in Appendix 2). A change of crew on the last day of the trial bought about some variations in average cycle times, but these were not considered significant.

6.2.1 Study Method

Two LIRA staff members carried out the production study, which was run in unfavourable climatic conditions. All haul distances were pre-measured and marked the day before. The element timer was located at the bush end of the operation and could see the whole cycle, apart from minor delays that may have occurred during unstropping on the landing. A Cronas MT2 digital stopwatch was used in a flyback recording method. The scaler was working on the landing and measured the length and small end diameter of all extracted pieces. Log volumes were then calculated using Kaingaroa log volume tables. A description of the elements, and the break point between elements is contained in Appendix 1.

6.3 Trial Results

The trial results are best expressed in chart form to give an accurate breakdown of how each cycle was constructed. These figures should be considered indicative of the hauler's capacity, working in the particular circumstances peculiar to harvesting windthrow in unfavourable conditions. If anything the results under estimate the machine's potential in a normal logging operation. To satisfy the manufacturers warranty conditions the hauler engine was governed to 2,000 rpm (59 kW) for the first 100 hours, and the production trials were run during this period. Although the governed H.P. did not affect line pull, it did reduce the line speed considerably. Line speeds will show a significant increase at the higher H.P. setting. Rope capacity on the drums was reduced to 457 metres of skyline and mainline, and 945 metres of tailrope, to suit the operating conditions.

Chart of Productive Cycle in Lotus Series II trials

Element	Total Time	Average Time	Comments
Raise rigging	14.43	.13	
Outhaul	99.90	.90	125 m average 2.31 M/S or 454 ft/min
Lower skyline	16.65	.15	
Move in	17.76	.16	
Sort strops	26.64	.24	
Pull slack	74.37	.67	13.4 m average
Attach strops	57.72	.52	
Move clear	29.97	.27	
Raise skyline	28.86	.26	
Breakout	59.94	.54	146 longs 40 shorts
Inhaul	130.98	1.18	124 m average 1.75 M/S or 344 ft/min
Lower rigging	22.20	.20	
Unstrop	65.49	.59	
Delays	47.73	.43	
TOTAL	692.64	6.24	

A skyline shift, including rigging a tail spar (approximately 7.5 metres up the tree) took 69.96 minutes. A total of 146 longs, and 40 shorts, were produced during the trials with an average volume of .84 m^3 per log. The average turn size was 1.68 pieces, and average turn volume 1.4 m^3 .

The average haul distance was 124 metres over the two days. Because pulling mainrope slack was made easy by the operator being able to power the drum out, a wider than usual swathe was logged with each skyline setting. This swathe width was over 40 metres at the rear of each setting.

6.4 Machine Availability

During the trial period, machine availability and utilisation was 95% and 86% respectively. The higher than average utilisation is directly attributable to a well organised productive crew.

6.5 Summary

From the production study data shown in the chart, the following estimations of machine productivity can be made. Assuming a 6½ hour machine day, over a 125 metre haul distance, the hauler should be capable of doing 62.5 turns per day.

i.e. 390 minutes ÷ 6.24 minutes = 62.5 cycles per day.

If a total of 186 pieces were produced over 111 turns, the hauler extracted an average of 1.68 pieces per turn.

$186 \div 111 = 1.68$ pieces per turn.

To take the calculation further, assuming an average volume of .84 m^3 then,

$1.68 \times .84\ m^3 = 1.41\ m^3$ per turn.

Working on the basis of 62.5 turns, then,

$1.41\ m^3 \times 62.5 = 88\ m^3$ per day.

This figure is an estimation derived from the two day study, and may not be applicable in all circumstances. The element and cycle times are actual, averaged times from the study, and no allowance has been made for the expected increase in line speed, or the usual work study allowances for personal delays, interruptions, etc. It is, however, substantiated by the Tauhara weighbridge figure which records the daily production from gang 29 (the Series II Lotus crew) at 84.5 tonne per day average.

SECTION 7

TRIAL PROBLEMS

This section of the report deals with the problems encountered during the trials. For a new design there were surprisingly few machine performance problems and those that did occur were relatively minor.

The major problem area, and the cause of most delay was in the use, and subsequent replacement, of non-specified components in the machine construction by sub-contractors, and the supply of ancillary supplies for the trials.

Machine Fabrication and Assembly

The Lotus haulers are built in a two-stage process. The fabrication of the hauler frame is completed and then sent for the installation of the hydraulic components. When this is complete the hauler frame is returned to the engineering company who mount it on the carrier unit.

7.1 Engineering

The engineering company who built the Series II are a small Auckland based company who specialise in the fabrication and assembly of metal components. They have been responsible for the fabrication and assembly of the Lotus haulers to date, including the Jamaican machines. There have been no problems with their previous work, but with this machine it was found that :

7.1.01 The backing plate for the main hydraulic pump, and engine flywheel coupling, was .045 in. out, which caused considerable damage to the engine crankshaft and bearings. The crankshaft had to be reground and all bearings replaced.

7.1.02 The lateral stabiliser supports and gussets were not fitted as per the original plan. Additional gussets had to be put in to prevent the truck chassis twisting.

7.1.03 The tower hinge pin retaining lugs were slightly out of alignment, which will be a constant problem when machine shifts require the tower to be dropped and hinged. The hinge bolt can be removed and replaced even though the lugs are not in true alignment, but a degree of force is required.

7.2 Hydraulic Componentry

Some errors were made in the choice of hydraulic componentry and its assembly for the Series II hauler; and the standard of service and parts back up, during the initial trial period, left a lot to be desired. The main problems were :

7.2.01 The hydraulic pump was specified with a splined shaft coupling to the engine flywheel. The pump supplied had a straight shaft and ke·way. When the key broke and had to be replaced it was found that t[illegible] [illegible]y was not the original.

7.2.02 A relief valve on the strawline hydraulic motor circuit [illegible] during assembly.

7.2.03 The electrical wiring was carried out by a sub-contr[illegible] trials it was found that some circuits had been wired [illegible] electrician was called in to re-wire those circuits that required it. The circuit wiring was not colour coded as requested and the wire gauge was too light.

7.2.04 The field service reps were very competent, available on call at any time, and were willing to work the hours required to get the machine running again. The backup they received from the factory during the initial trial period was poor, as was the level and standard of the field service equipment carried.

As a result of these problems, the management of the component suppliers hydraulic's division was changed during the trial period. The new division management proved to be both service and customer oriented and the improvement in the level of the service can be complimented.

7.3 Communications

There were no suitable signal only, or voice signal, communications systems available off the shelf, as local agents will not carry stock for a low demand item.

The most suitable signalling systems are imported, although there was an attempt made to design and manufacture a single and dual frequency signal only system in New Zealand. This was dropped through lack of industry demand.

For the trials a base and hand held radio, using a UHF frequency, was purchased. As a special battery was required to run the hand held set, and as this battery was not properly charged, two days were lost while the local agent tried to find why it would not transmit. Unfortunately, his test bed isolated the battery in favour of mains power, hence he could find no fault.

Once the battery was fully charged the radio worked well, with sound and clarity both good, but the hand held was subject to a degree of abuse because it was awkward to carry, and use, during breakout.

Portable hand held radios would not be recommended if voice signal, or signal only systems were available.

7.4 Rigging

Prior to the trials it became very apparent that a lot of the rigging used in small hauler operations, such as tail rope blocks, swivels, chains, connectors, etc., is not readily available.

Given the amount of rigging needed to set up a hauler this was both surprising and disturbing. The major causes of this lack of availability appear to be the lack of consistent demand from the industry, the small number of machines in operation, and the larger industry companies who bulk purchase or tender.

Prior to the trials there was also a lack of communication between the machine manufacturer and the rigging supplier on the likely rigging requirements. For the trials it was not possible to put together a set of matched rigging for 13 mm rope in a northbend system, from any, or even a combination of all dealers, so a set of rigging was made up of miscellaneous under and over-sized components.

7.5 Carriage

The carriage used for the trials was supplied by Lotus Enterprises Ltd, and was a standard three sheave skyline carriage design.

Although it was similar in design and looks to a purpose-built carriage, it was built by an engineering shop in Auckland. The standard of manufacture, and assembly, of this carriage was very poor, and the carriage was the major cause of the rope deformation and damage that occurred in the skyline. Particular faults noted, were :

7.5.01 The two skyline sheaves had not been aligned with the side plates or bottom sheave, so the carriage would not run true under load. After a short period of time (two weeks), deformation of both the skyline and carriage sheaves was apparent.

7.5.02 A reject sheave had been welded into the back of the carriage for a tail hold, but it was impossible to use a shackle to connect the tail rope to the carriage because of the depth of the sheave and the way the sheave was inserted between the side plates. A guyline shackle could have been used if a section of the side plates had been cut out.

7.5.03 After one month's use the skyline sheaves had worn excessively, to the extent that the sheaves would not turn under load.

7.6 Machine Design

This is one area where it is difficult to completely separate design deficiencies or shortcomings from the specification approved by the machine's owner.

Suffice it to say thay there would be some design changes to suit New Zealand conditions.

Specific design deficiencies noted were :

7.6.01 The drum anchor for the skyline was on the flange between the split and storage sections of the drum, with the ferrule protruding onto the barrel of the split drum. Every time the split drum was used to tension the skyline the rope would lay over the ferrule causing rope deformation and damage. If the drum was reversed, the anchor could be on the side of the storage drum, thus eliminating the problem.

7.6.02 The guyline drum barrels were too small in diameter to get a good lay of rope on the drum, and there were problems in getting the first wraps to lay even. A more rigid rope (6 + 19) than the 19 mm 6 x 31 used, would be almost impossible to lay on the drum.

7.6.03 The existing flange guard on all drums should be extended to a full circle guard, to eliminate the possibility of the rope jumping the flange and wrapping around the drum drive shaft. Additional protection could be added by welding a short flat bar from the bottom edge of the drum guard to the drum housing, which would eliminate any possibility of the rope jumping the drum flange while driving slack.

7.6.04 The gap between the tower sheaves and the retaining brackets should be reduced to eliminate any possibility of the rope jumping the sheave and jamming between the sheave and bracket.

7.6.05 Brackets could be welded onto the side of the tower to enable guylines and running lines to be looped out of the way during machine shifts.

7.7 Summary

Although this section of the report is largely negative, it was pleasing to note the positive approach taken by reputable companies to resolve the problems that arose.

A rigid quality control programme has been instituted between the designer, the fabricator and the component supplier.

The management of the major component suppliers hydraulic division was changed midway through the trials, and with the support of their top management, have proved that they can offer a service second to none.

The problem of obtaining rigging for small haulers was not solved, but advance notice of the likely requirements of the machine manufacturer, to the rigging supplier, would ensure that the right rigging is available, and that stock levels to be carried are changed.

LIRA staff were involved in most of these problem areas, so obtained a very detailed insight into commonly talked about problems that have very little documented detail. This documentation will be useful to the industry in future discussions on import licencing and local manufacture.

SECTION 8

CONCLUSIONS

The objectives of the Lotus Series II trials were to firstly satisfy the Jamaican company, FIDCO, that the hauler met the agreed specifications, and to secondly evaluate the machine in a production situation to get an indication of how it would perform in a New Zealand operation. With the anticipated reduction in piece size, and the known increase in production expected from steeper areas, demand for a hauler of this capacity is likey to be high. LIRA's involvement was to act as an impartial body to test and certify the machine according to specification, and to investigate the report on the potential productivity of the Series II for the benefit of the New Zealand industry. It must be remembered that the machine under evaluation was built specifically for a Jamaican client and that certain features unsuitable for New Zealand operations would be altered or replaced.

The trial site, although not ideal, provided a more than adequate testing ground for the hauler. Piece size recorded at .84 m^3 average, fluctuated between short broken tops to full tree lengths over 1.8 m^3 in volume. Keith Travers and crew were well suited for the purpose of the trials, being both highly productive and amenable to trying new or different ideas. A daily production of 88 m^3 was determined from work study data gathered during the trials, and this was confirmed as realistic by the overall average daily production of 84.5 tonnes recorded at the weighbridge.

Although machine performance during the evaluation was impressive, the trials did not run without frustrations and delays. These problems seemed to stem right from hauler construction through to the acquiring of ancillary equipment necessary for the operation, but it was pleasing to note the positive approach taken by reputable companies to resolve the problems that arose and it is hoped that they will be examples to others in similar situations.

LIRA can confidently report that the Lotus Series II under trial not only met, but in some cases exceeded the performance requirements of the specification. The potential to increase power and speed make it a highly versatile machine that could be used in thinning or clearfelling, providing rope sizes are matched to the volume of timber per turn being yarded. The principles of using hydraulics open up a new concept of power and speed combinations which are likely to be manifested in future machines.

The New Zealand company of Lotus Enterprises Ltd must be commended for its perseverence in developing this concept to a production stage. It is hoped that the follow-up service will be as energetic as the development efforts.

In conclusion, these trials were not only testing the specification against performance of the Series II Lotus, they were also proving that hydraulic drive in haulers is both viable and highly competitive with existing equipment, both in New Zealand and overseas.

APPENDIX 1

ELEMENT DESCRIPTION

Each production cycle was broken up into 14 elements, which were recorded as they occurred. A brief description of these elements, and their break points, is outlined below.

1. Raise rigging. Began when the hauler engine was reved to raise the skyline. Ended when the skyline was tight.

2. Outhaul. Began when the tail rope started to move. Ended when the carriage was stopped on the skyline.

3. Lower skyline. Began when the breakerout signalled for the carriage to be lowered. Ended when the carriage was either stopped, or on the ground.

   Note: This could happen two or three times in some cycles, if the turn could not be broken out and logs had to be unstropped.

4. Move in. Began when the carriage was stopped. Ended when the breakerout first touched the strop.

5. Sort strops. Began when the strops were first touched. Ended when the selected strop was free.

   Note: This did not occur every turn.

6. Pull slack. Began when the breakerout started to walk out with the rope. Ended when the breakerout bent to attach the strop.

   Note: This was assisted by the hauler operator powering out slack on the drum.

7. Attach strops. Began when the breakerout bent to place the strop around the log. Ended when he stood up from attaching the last choker.

   Note: Sometimes done concurrently by two men.

8. Move clear. Began when the breakerout stood up from attaching strops. Ended when the signal was given to raise the skyline.

9. Raise skyline. Began when the breakerouts were clear. Ended when the skyline was tight.

   Note: This function often occurred more than once during the cycle and it was sometimes necessary during inhaul, if the force exerted on the skyline exceeded the relief valve setting which causes the skyline to slip tension.

10. Break out. Began when the skyline was tight. Ended when the logs were broken out and moving freely.

    Note: Break out attempts sometimes failed and logs had to be cut or unstropped. This is a common problem in windthrow logging as the breakerout cannot always tell if the turn is tail locked or otherwise obstructed.

11. Inhaul. Began when logs were clearly broken out. Ended when the carriage stopped at the end of the haul rope.

12. Lower rigging. Began when the carriage stopped on the skyline. Ended when all lines were slack.

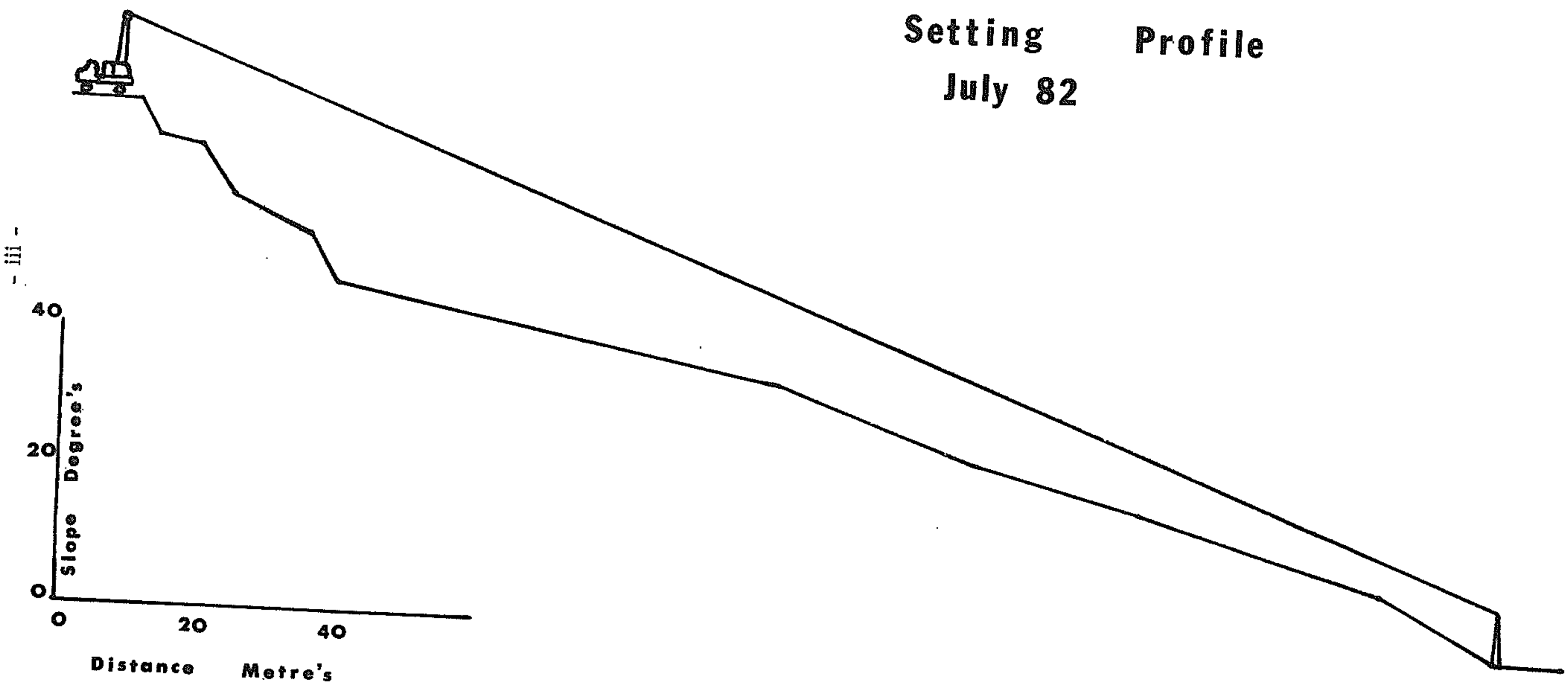
    Note: Sometimes problems were encountered with the carriage running back down the skyline, which is a common problem in a live skyline system pulling uphill.

13. Unstrop. Began when all lines were slack. Ended when the hauler engine was reved to raise the skyline.

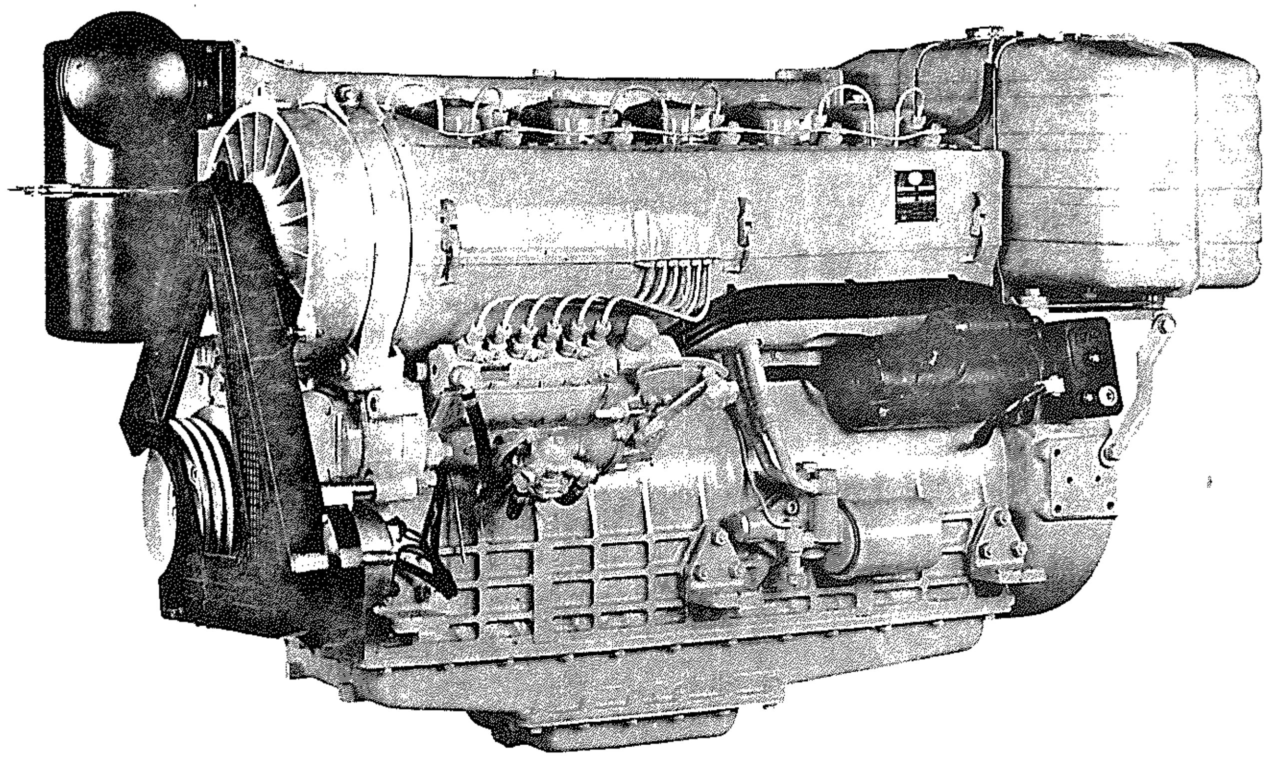
14. Delays, are timed production delays where the operation is stopped by other activities, i.e. waiting for the skidder to move clear, waiting for a breakerout to cut a log, etc.

APPENDIX 2

LOTUS Series 11 Trials
Tauhara Forest
Setting Profile
July 82



VM DIESEL



1056 SU

Cilindri	Cylinders	Cylindres	n°	6
Alesaggio	Bore	Alésage	mm	105
Corsa	Stroke	Course	mm	110
Cilindrata totale	Total swept volume	Cylindrée	lt	5,712
Giri max.	Max. speed R.P.M.	Tours max.	n°/1'	2800
Potenza massima SAE	Maximum SAE rating	Puissance max. SAE	CV	132
Potenza massima «F» (DIN 70020) a 2800 n°/1'	Maximum rating «F» (DIN 70020) at 2800 R.P.M.	Puissance max. «F» (DIN 70020) à 2800 Tr/mn	CV	120
Potenza continua «B» (DIN 6270) a 2600 n°/1'	Continuous rating «B» (DIN 6270) at 2600 R.P.M.	Puissance cont. «B» (DIN 6270) à 2600 Tr/mn	CV	112,5
Potenza continua «A» (DIN 6270) a 2500 n°/1'	Continuous rating «A» (DIN 6270) at 2500 R.P.M.	Puissance cont. «A» (IDIN 6270) à 2500 Tr/mn	CV	105
Rapporto di compressione	Compression ratio	Taux de compression		17 : 1
Cuscinetti di banco	Main bearings	Coussinets de palier	n°	7
Consumo specifico combustibile (potenza «B»)	Fuel specific consumption (power «B»)	Consommation de combustible (puissance «B»)	g/CV h	174
Consumo specifico combustibile (potenza «A»)	Fuel specific consumption (power «A»)	Consommation de combustible (puissance «A»)	g/CV h	170
Consumo specifico lubrificante	Oil specific consumption	Consommation de lubrifiant	g/CV h	0,5÷1
Velocità minima a vuoto	Minimum speed at idling	Vitesse minimum de ralenti	n°/1'	600
Velocità minima per servizio continuo	Minimum speed at continuous duty	Vitesse minimum de service continu	n°/1'	1200
Inclinazione longitudinale ammissibile	Max. permissible engine tilt angles: front or rear down	Inclinaison admissible en avant ou en arrière		20°
Inclinazione trasversale ammissibile	Max. permissible engine tilt angles: left or right sides down	Inclinaison admissible à droite ou à gauche		40°
Peso netto con avviamento elettrico	Net weight with electric starter	Poids net moteur à démarrage électrique	Kg	555
Peso imballo via terra	Land-packing weight	Poids de l'emballage terre	Kg	110
Peso imballo via mare	Sea-packing weight	Poids de l'emballage maritime	Kg	170
Volume imballo	Packing volume	Cubage	m³	1,68

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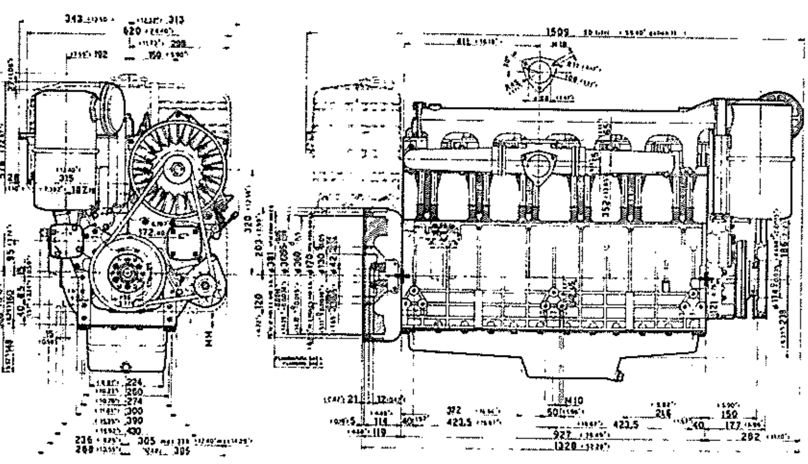
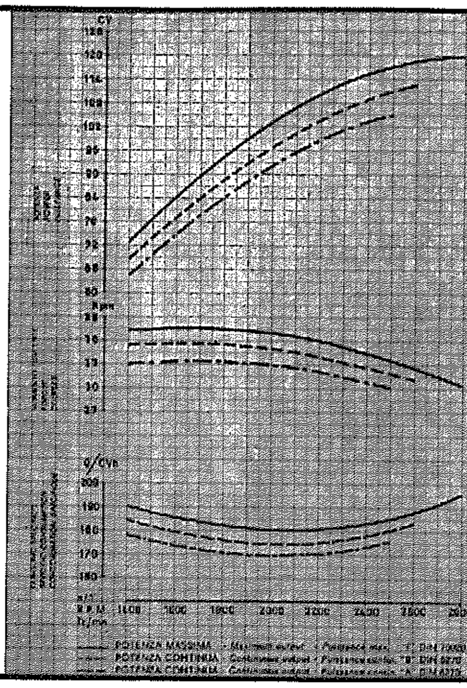




CARATTERISTICHE GENERALI

Motore a ciclo diesel, quattro tempi - iniezione diretta - raffreddamento ad aria con soffiante assiale - regolatore centrifugo automatico - lubrificazione forzata con pompa a rotori - alimentazione con pompetta a membrana - filtri del lubrificante e del carburante, a cartuccia integrale - filtro dell'aria a bagno d'olio.

DATI COSTRUTTIVI: teste in ghisa speciale - cilindri in ghisa perlitica centrifugata - pistoni in lega leggera - bielle in acciaio stampato e trattato - basamento in ghisa speciale - albero motore in acciaio stampato e trattato - albero a camme in acciaio cementato e temperato - cuscinetti di testa biella e di banco in acciaio rivestito con lega alluminio/stagno a struttura reticolare.

ENTITÀ DI FORNITURA: motore standard completo di filtro aria a bagno d'olio - leva comando acceleratore a mano con pomello di arresto - serbatoio del combustibile - spegnifiamma - copricinghie - tendicinghie - staffe supporto - manovella - borsa attrezzi.

APPLICAZIONI A RICHIESTA

VARIE: dispositivo di avviamento elettrico a 12 V costituito da: corona dentata sul volano, avviatore da 4 CV, alternatore da 400 W, regolatore di tensione, cruscotto e collegamenti - batteria da 110 Ah oppure 180 Ah - innesto a denti per manovella - dispositivo alzavalvole - filtro aria a bagno d'olio con prefiltro a ciclone - comando acceleratore a distanza - manometro olio montato sul cruscotto - contaore meccanico - contagiri/contaore con rinvio e trasmissione di mm 2000 - termoavviatore per climi rigidi (applicabile solamente con impianto elettrico) - start pilote per avviamento in climi rigidi - convogliatore per lo scarico dell'aria calda - elettromagnete di stop completo di servorelè - pompa estrazione olio dalla coppa - staffe supporto speciali complete di supporti elastici - marmitta silenziatrice.

ANTERIORI: gruppo di trasmissione per compressore d'aria su presa di forza sinistra - gruppo di trasmissione per compressore d'aria su presa di forza destra - predisposizione per applicazione pompa oleodinamica su asse motore - predisposizione per applicazione pompa oleodinamica su presa di forza sinistra - predisposizione per applicazione pompa oleodinamica su presa di forza destra.

POSTERIORI: contralbero per trasmissioni a cinghie - frizione monodisco a secco con contralbero per accoppiamenti assiali ad impiego intermittente - frizione industriale a punto morto completa di contralbero - cambio di velocità a 4 rapporti + R.M. completo di frizione - predisposizione per cambi di velocità - volano per gruppo elettrogeno - giunto elastico applicato sul volano completo di controgiunto con foro grezzo - campana e giunto per applicazione pompa oleodinamica - riduttore/moltiplicatore di giri nei 2 sensi di rotazione, con o senza frizione - accoppiatore a 2 o 3 prese per pompe oleodinamiche.

GENERAL FEATURES

Diesel engine, 4 stroke - direct injection - air-cooling by axial blower - automatic centrifugal governor - force-feed lubrication by rotors pump - diaphragm pump feed - complete cartridge oil and fuel filters - oil-bath air filter.

STRUCTURE: heads in special cast-iron - cylinders in centrifugally pearlitic cast-iron - light alloy pistons - drop-forged and treated steel connecting rods - special cast-iron crankcase - drop-forged and treated steel crankshaft - casehardened and tempered steel camshaft - steel main and big end bearings reticular aluminium/tin lined.

STANDARD SUPPLY: engine complete of oil-bath air filter - manual throttle control lever with stop knob - fuel tank - flame-trap - belts-cover - belts-stretcher - engine brackets - cranking handle - tools kit.

OPTIONALS

12 Volt electric starting device with, crown gear on flywheel, 4 HP starter, 400 Watt alternator, voltage regulator, dashboard and connections, 110 Ah or 180 Ah battery - claw clutch for hand start - decompressione device - oil-bath air filter with cyclone precleaner - dual oil-bath air filter for dusty conditions - remote start control - oil pressure gauge mounted on control panel - mechanical hourmeter - hourmeter/speed indicator with driving unit and 6.5 ft of cable - induction heater thermal starter (electric start only) - cold weather start pilot - hot air outlet duct - electromagnetic stop with relay - scavenge oil pump - special brackets with flexible supports - silencer.

FRONT SIDE: air compressor adaptor for left P.T.O. - air compressor adaptor for right P.T.O. - hydraulic pump adaptor for crankshaft axle - hydraulic pump adaptor for left P.T.O. - hydraulic pump adaptor for right P.T.O.

REAR SIDE: countershaft for belt-drive - dry single-plate clutch with stub shaft for axial drive at intermittent duty - overcenter clutch with stubshaft - clutch and gearbox with 4 gears ahead and 1 back wards - gearbox adaptor - flywheel for generating duty - flexible coupling on flywheel with rough bored extension - housing and coupling for hydraulic pump application - clockwise and counter clockwise reduction-overdrive gear with or without clutch - adaptor for 2 or 3 P.T.O. for hydraulic pumps.

CARACTERISTIQUES GENERALES

Moteur Diesel à quatre temps - injection directe - refroidissement par air avec soufflante axiale - régulateur centrifuge automatique - lubrificatio forcée par pompe à rotors - alimentation par pompe à membrane - filtres du lubrifiant et du carburant à cartouche - filtre à air à bain d'huile.

DONNÉES DE CONSTRUCTION: culasses en fonte spéciale - cylindres en fonte perlitique centrifugée - pistons en alliage léger - bielle en acier estampé et traité - bâti en fonte spéciale - vilebrequin en acier estampé et traité - arbre à cames en acier cémenté et trempé - coussinets de tête de bielle et de palier en acier revêtu d'aluminium/étain en alliage à structure réticulaire.

FOURNITURE: moteur standard complet de filtre à air à bain d'huile - levier commande accélérateur à main avec bouton d'arrêt - réservoir à combustible - pot d'échappement - couvre-courroies - tendeur de courroies - pieds de support - manivelle - trousse à outils.

SUR DEMANDE

Dispositif de démarrage électrique à 12 V composé de: couronne dentée sur le volant, démarreur 4 HP, alternateur 400 W avec support, régulateur de tension, tableau de commande et liaisons - batterie 110 Ah ou 180 Ah - embrayage à dents pour manivelle - dispositif pour levée des soupapes - filtre à air à bain d'huile avec préfiltre à cyclone - filtre à air à bain d'huile à double corps pour milieux poussiéreux - commande accélérateur à distance - manomètre à huile monté sur le tableau de commande - compteur horaire mécanique - comptetours/compteur horaire avec renvoi et transmission de 2000 mm - thermodémarreur pour climats rigides (à appliquer avec équipement électrique seulement) - start pilote pour climats rigides - convoyeur pour l'échappement de l'air chaud - électro-aimant de stop complet de servo-relais - pompe de vidange d'huile du carter - supports spéciaux complets de contre-supports et amortisseurs de vibrations - pot d'échappement.

A L'AVANT: groupe de transmission pour compresseur d'air sur prise de force gauche - groupe de transmission pour compresseur d'air sur prise de force droite - prédisposition pour l'application de pompe oléodynamique sur l'axe moteur - prédisposition pour l'application pompe oléodynamique sur prise de force gauche - prédisposition pour l'application pompe oléodynamique sur prise de force droite.

A L'ARRIÈRE: contre-arbre pour transmissions par courroies - embrayage monodisque à sec avec contre-arbre pour accouplements axiaux à service intermittent - embrayage industriel à point mort complet de contre-arbre - boîte de vitesses à 4 rapports + 1 A.R., complète d'embrayage - prédisposition pour boîte de vitesses - volant pour groupe électrogène - joint élastique appliqué sur le volant, complet de contre-joint avec trou non usiné - cloche et joint pour application de pompe oléodynamique - réducteur/multiplicateur de tours dans les 2 sens de rotation, avec ou sans embrayage - adaptation pour 2 ou 3 prise de force pour pompes hydrauliques.

Illustrazioni e caratteristiche non impegnative — Illustrations and data are not binding — Les caractéristiques et illustrations ne sont pas engageantes

STABILIMENTI MECCANICI VM S.p.A.

Stabilimento di TRIESTE: Zona Industriale - Tel. 040/817321 (ric. aut.) - Telegr. VIEMME TRIESTE - Telex 460277 VIEMME

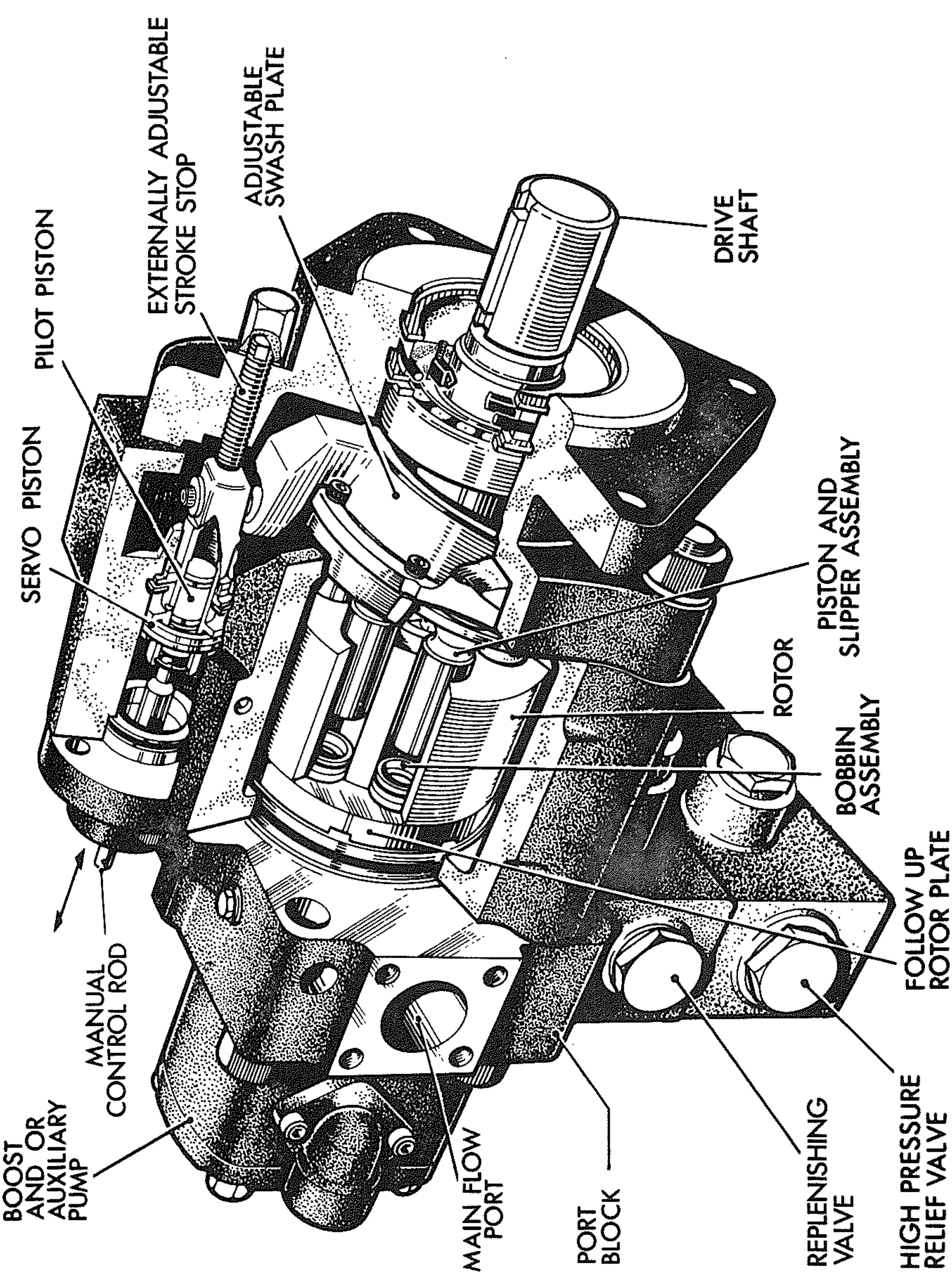
Stabilimento di CENTO (FE): Via Ferrarese, 29 - Tel. 051/901090 (ric. aut.) - Telegr. VIEMME CENTO - Telex 510462-511642 VIEMME

Agip

Mod. 016'31 - PUBBLISTUDIO VIEMME

M3 979 SIACA ARTI GRAFICHE GIANNI TASSINARI - 44042 CENTO (FERRARA) ITALY

HD2 series



A Typical HD2 Series Variable Capacity Unit

HD2 series

Product Support

Overseas Associated companies and agents around the world.

Applications Engineers to design your system and give advice.

Commissioning Engineers available to assist with start up of new systems.

Service Engineers available for on site problems and routine inspection.

Exchange Scheme fully guaranteed service exchange units available.

Spare Parts for customers who wish to do their own repair work, service kits for minor repairs.

Power Packs equipment can be supplied as complete power packs with diesel or electric prime movers, complete with all ancillary equipment.

Ordering Code

HD2 / Size / Shaft / Replenishing Valve / High Pressure Relief Valve / Auxiliary Pump Mounting / Auxiliary Pump Type Number / Control / Add any special feature if required.

Size

- 900
- 1400
- 2200
- 3000
- 4000

Shaft

- 20 Key
- 21 Spline

Replenishing Valve

- 30

High Pressure Relief Valve

- 35

Auxiliary Pump Mounting

- 41 3PA
- 42 3·5PA
- 43 4PA
- 48 SAE "C" 4 Bolt — Will be superceded by 50 and 51
- 49 SAE "B" 4 Bolt — Will be superceded by 50 and 51
- 50 SAE "B" 2 and 4 Bolt
- 51 SAE "C" 2 and 4 Bolt
- 52 SAE "D" 2 and 4 Bolt

Auxiliary Pump Type Number

Add any special feature if required.

e.g. Inlet and outlet port flanges for main pump

Control

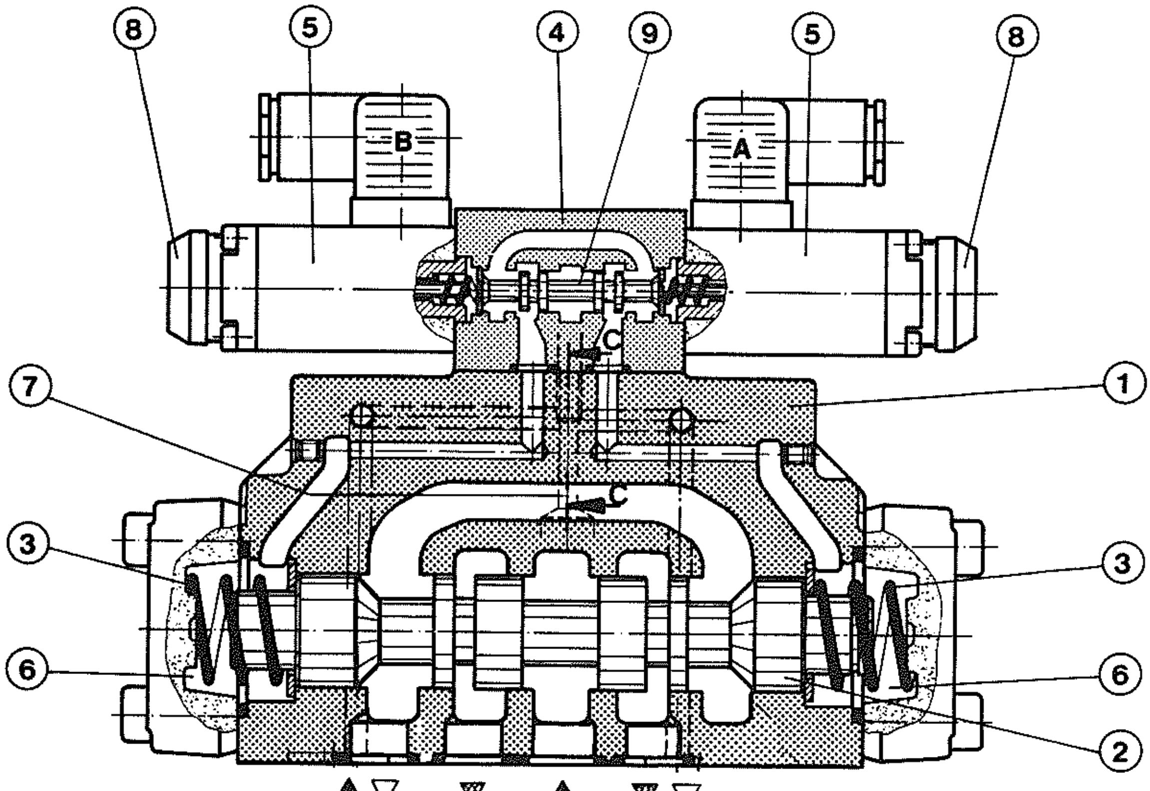
1	F										
2	MS										
3	MSNS										
4	MAMS										
5	OCR	5A	OCR/CHP/P	5B	OCR/P	5C	OCR/CHP				
6	CPSV	6A	CPR	6B	CPM	6C	TC	6D	CPSVP	6E	CPRF
7	MSSV	7A	MASV	7B	MSSVP						
8	EH										
9	CHP	9A	CHP/P	9B	CHP/D						
12	CD										

For 5A and 5C Add Input Power and Speed

For 9A and 9B: Add Input Power and Speed

Example: HD2/4000/5/20/30/35/51/P30 C 678 BE OL 15-7

Description of Function, Section



Type 4 WEH 22...60/..6A..

Directional valves type WEH

Directional valves type WEH are directional spool valves with a solenoid operated pilot valve. They control starting, stopping and the direction of a flow.
These directional control valves comprise mainly the main valve with housing (1), the control spool (2), one or two return springs (3), and the pilot valve (4) with one or two solenoids (5).
The control spool of the main valve is held in zero or starting position by means of springs or pressure.
In starting position, the spring chambers (6) are connected to tank without pressure by means of the pilot valve.
Fluid is supplied to the pilot valve (4) by means of the control line (7). Oil supply can be either internal or external (external via "X").
The control spool (2) is operated hydraulically by means of the pilot valve, fitted with DC or AC oil immersed solenoids (5).
When the pilot valve is actuated, control pressure affects one of the two ends of the control spool (2) and pushes this into the switching position. This opens the switching position required: P to A and B to T or P to B and A to T.
When the solenoid is de-energised, the pilot valve returns to the starting position (with the exception of impulse spool valves). The spring chamber (6) is unloaded to tank.
The control fluid is pushed from the spring chamber into the Y line via the pilot valve by the spring lying opposite.
The fluid can be drained internally or externally (externally via "Y").
A hand emergency device (8) can be fitted, which allows the control spool (9) to be moved without energising the solenoid.

4/2 Way Valve

Four different models are available:

1. Type 4 WEH.../...

Pilot valve and main valve each have one return spring to fix the spool end position (guaranteed switching even if power fails).

2. Type 4 WEH..H..

The pilot valve has one return spring, which holds the control spool in end position.
The main control spool must be fixed in end position by pressure.

3. Type 4 WEH..H../O..

The pilot valve has 2 solenoids. There are no return springs in the pilot or main valve.
Spool positions are therefore determined by solenoid energisation and pressure.
One solenoid must therefore be energised constantly.

4. Type 4 WEH..H../OF

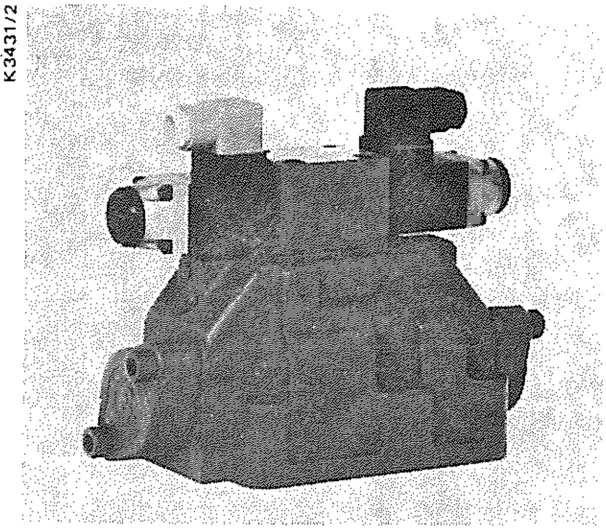
The pilot valve has 2 solenoids, and the control spool is held in position by detents (impulse spool valve).
The main control spool has no detents, but moves into position when pressurised.

On types 2, 3 and 4 the spool is in a defined position only when pilot pressure is applied to the valve.

MANNESMANN REXROTH	4/3 and 4/2 Directional Control Valves Type WEH 22 Series 60			RE 24 766/9.81
	Size 25	to 280 bar	to 450 l/min	Replaces: 8.80

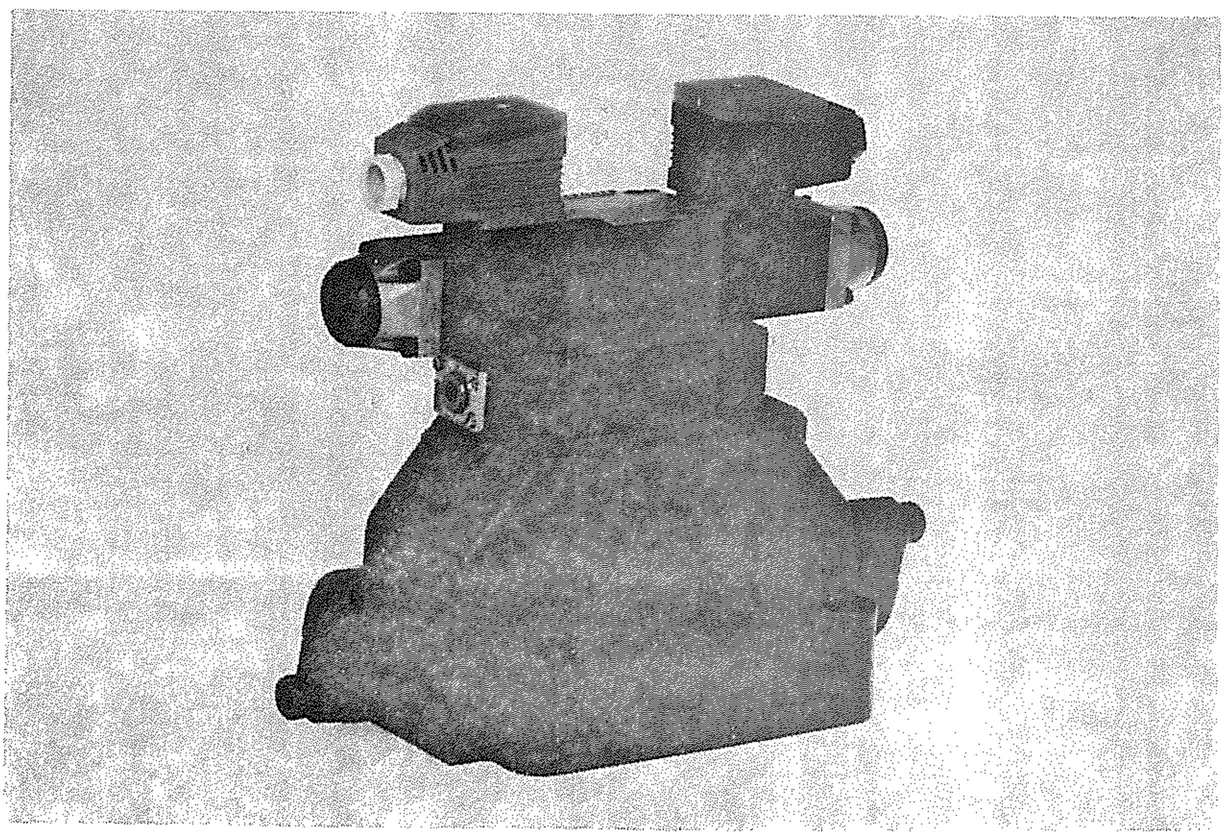
- pilot operated directional spool valve with solenoid control
- connection dimensions to DIN 24 340, Form A, size 25
- subplate mounting
- DC or AC oil immersed solenoids, optional
- with or without hand emergency
- individual or central electrical connection
- spring centering, spring or pressure return of the main control spool to starting position
- pilot choke adjustment
- stroke limiting and/or end position monitering of the main spool
- end position monitering for main spool, either by limit switches or inductive procimity device
- pilot pressure insert in P line of main valve
- throttle insert to reduce pilot supply
- pressure valve to reduce pilot pressure with control pressure in excess of 210 bar up to 315 bar
- 19 standard symbols

K3431/2



Type 4 WEH 22 ...60/..6A..N24

K3429/2



Type 4 WEH 22 ...60/..6A..NS25